ENVIRONMENTAL STUDIES IN THE TIMMINS AREA

(1970-1975)

Northeastern Region
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1. Introduction:

In November 1966, the Ecstall Mining Company, a wholly-owned subsidiary of Texasgulf Incorporated began operation of an ore concentrator in the southeast corner of Hoyle Township, about 20 kilometres northeast of Timmins, Ontario. This concentrator has been producing two grades of zinc concentrate and one grade of lead concentrate with cadmium as a secondary constituent since that date. In April 1972, the Company began operation of an electrolytic zinc plant (smelter and refinery) adjacent to the ore concentrator. Zinc and cadmium are produced in the refinery and sulphuric acid is a by-product of the process as a result of the conversion of sulphur dioxide from the roaster gas to liquid sulphuric acid. The construction of this complex was conducted under the approval of the Ministry of the Environment with the intention that the emissions from this plant would meet Government regulations with regard to ambient air quality.

Recently Texasgulf Incorporated has announced plans for expansion of their Timmins operations. This expansion could include a copper smelter and refinery, a lead plant, a fertilizer plant and possibly a cement plant. The Company is working closely with the Ministry of the Environment on this program to insure that environmental deterioration will not result from the operation of this planned industrial complex. The Ministry will continue to monitor various environmental parameters and the data gathered to date from previous studies will serve as baseline information for evaluation of the performance of new installations.

Prior to the opening of the zinc plant, fears had been expressed that widespread environmental damage might occur in the Timmins area as a result of the operation of the refinery. Therefore in order to determine the environmental impact of the air borne emissions from this plant, the Ministry of the Environment developed a program to monitor the air quality, vegetation and soils two years prior to the scheduled opening of the refinery. In 1970, a network of 10 study plots, with the zinc plant as the focal point, was established ranging up to 32 kilometres from the plant. In addition, two control plots each 80 km. from the plant, were established.

After studying the data available since 1970, this survey was re-aligned in October, 1973. At that time, several of the more remote plots were discontinued and several new plots were established closer to the source. Also, in the 1973 and 1974 growing seasons, close attention was given to the vegetation and soils in the immediate vicinity of the refinery complex. As well, a snow sampling program was initiated in the winter months of 1974 and repeated during the winter of 1975.

This report outlines the data available to date and also summarizes the adjustments in the program which have resulted from an evaluation of the data obtained in the original survey.

II. Plot Establishment and Program Outline:

During the growing season of 1970, ten surveillance plots and two control plots were established at the following locations by the Ontario Ministry of the Environment.

Plot Number	Distance and Direction From the Zinc Plant
1	1.6 km NE
2	3.2 km NE
3	8.0 km NE
4	16.1 km NE
5	32.2 km NE
6	8.0 km E
7	16.1 km E
8	32.2 km E
9	16.1 km SW
10	32.2 km SW
11	80.0 km SW
12	80.0 km E

(See Appendix for map and plot locations and site descriptions, Figure 1)

During the 1970 growing season each of these plots was visited only once, since the establishment of such a network was a lengthy project. However, from 1971 to 1973, all twelve plots were inspected monthly from May to October.

At the time of the 1970 visit, 20 trembling aspen trees and 10 shrubs (alder, hazel, mountain maple or choke cherry) were tagged in a 22 x 22 metre area at each plot. The "crown condition" of the trees was recorded, along with insect or disease injury, in order to establish a history of the vegetation on the plots. These conditions were again noted during each month of the growing seasons from 1971 to 1973. As well, in September of each year, the heights and diameters of the tagged trees were recorded for use in growth studies.

In 1970, at each plot, two 1.0 x 1.0 metre ground cover vegetation grids were established and the number and species of each type of plant found on these grids were recorded to determine any future fluctuations in plant populations. These grids were re-examined in August 1971, 1972 and 1973.

A program of sampling the vegetation and soil for chemical analysis was initiated in the vicinity of each plot established in 1970. Leaf samples from trembling aspen, white birch, alder (or substitute), white spruce, forage, soil and water were collected and analysed for fluoride, total sulphur, arsenic, cadmium, iron and zinc. In June, July and August 1971, this program was expanded to add jack pine, white spruce

and beaked hazel (or substitute) to the sampled materials. These samples were analysed for total sulphur, silver, arsenic, cadmium, copper, iron, lead and zinc. In 1972 and 1973, this sampling was repeated in June, July and August and the samples were similarly analysed.

Examination of the data obtained from 1970 to 1973 indicated that the environmental impact of the refinery with regard to vegetation and soils was localized in the vicinity of the zinc plant and that widespread problems were not being encountered. These facts resulted in a re-alignment of the surveillance program for the 1974 season. Accordingly, the plots which were 32 km. east, northeast and southwest; and 80 km. east and southwest were removed from the survey. Also, the original plot #1 (1.6 km northeast) was destroyed by logging. The more remote plots could easily be re-activated, if indications showed that such action was necessary, especially in view of the planned expansion program.

To replace the remote plots, 4 new plots were established in October, 1973, in the following locations with relation to the zinc plant:

.8 km northeast

1.6 km northeast

.8 km southwest

1.6 km southwest

In May, 1974, a new control plot was established approximately 32 kilometres west-southwest of the zinc plant.

The plot numbers then were re-assigned as follows:

Plot Number	Distance and Direction From the Zinc Plant
1	0.8 km NE
2	1.6 km NE
3	3.2 km NE
4	8.0 km NE
5	16.1 km NE
6	8.0 km E
7	16.1 km E
8	0.8 km SW
9	1.6 km SW
10	16.1 km SW
11	32.2 km WSW

(See Appendix for map and plot locations and site descriptions, Figure 2)

As in the original plots, 20 trembling aspen trees and 10 shrubs were tagged in a 22 metre x 22 metre area. The crown condition, height and diameter of each tree was recorded for use in growth studies. Ground cover vegetation grids were not established at the new plots. Since the data base for the levels of several chemical elements in vegetation had been established from earlier work the vegetation sampling program in 1974 was reduced to include only the foliage of trembling aspen, white spruce and forage. These samples were analyzed for sulphur, cadmium, chlorine, copper, iron, lead and zinc. Soil samples were collected from three depths at each location (0-5 cm., 5-10 cm., and 10-15 cm.) and analysed for sulphur, cadmium, chlorine, copper, iron, lead, zinc, calcium, magnesium and pH. Vegetation and soil samples were collected only in July and August during 1974.

In 1971, a lead peroxide candle, to measure ambient levels of sulphur dioxide, was set out at each of the vegetation plots and these candles were exchanged at monthly intervals throughout the 1971, 1972 and 1973 growing seasons. During the winter, the candles were left at each station for the period October until May.

For the 1974 growing season the candle survey was altered to correspond with the vegetation surveillance stations.

A program of snow sampling was established in the Timmins area during the 1974 winter months. Samples were collected at several locations around the zinc plant in January, February and March. The samples were melted and the pH determined for the melt water. The samples were analysed for sulphur, arsenic, cadmium, chlorine, copper, iron, nickel, lead, tin and zinc content. This program was continued in 1975. The locations of the sampling sites are shown in Figure 4.

III Observations:

(a) Sulphur Dioxide Injury to Vegetation:

During the July, 1974 surveillance visit to the Timmins area, the first evidence of sulphur dioxide injury to vegetation in the vicinity of the zinc refinery was encountered. Moderate (16-35% of leaf area affected) to severe (over 35% of leaf area affected) sulphur dioxide injury was noted on trembling aspen, white birch, serviceberry and pin cherry. The area over which this injury occurred was restricted to approximately one acre which was located 100 to 200 metres to the southwest of the zinc refinery, on company property.

During the August, 1974 surveillance visit extensive injury to vegetation was noted to the east of the refinery complex. The Company reported to the Ministry of the Environment that on July 27th., a malfunction had occurred in the process of converting sulphur dioxide to sulphuric acid resulting in the release of the sulphur dioxide to the atmosphere. Moderate to severe sulphur dioxide injury occurred to vegetation within the area bounded by the dotted line in Figure 3. Within this area the injury was located in pockets of varying sizes,

often along exposed edges of wooded areas. Many plant species showed typical SO_2 injury patterns. Some of the injured species are listed below:

trembling aspen	willow
white birch	bullrushes
balsam poplar	cow parsnip
large-tooth aspen	bracken fern
serviceberry	dogwood
speckled alder	spreading dogbane
viburnum	trillium

In the three years which the zinc refinery has been in operation, this was the first record of sulphur dioxide injury to vegetation outside of the company property limits.

(b) Vegetation Injury at the Study Plots:

During 1974, the first record of injury to the vegetation located on the study plots was recorded. As was noted above sulphur dioxide injury occurred to the trees, shrubs and herbaceous plants on plot #1 (0.8 km NE of the zinc plant). Injury also occurred to vegetation located in the vicinity of the original plot #1.

However, as has been pointed out in previous annual reports, no visible, acute, vegetation injury, which could be ascribed to the effects of air pollutants, was found at any of the remaining plots. Various insect pests and plant pathogenic fungi were found to be causing injury to several plant species at many of the plots. However, most of these problems were minor in nature.

Vegetation injury (other than SO_2) was observed in the immediate vicinity of the zinc plant in 1973 and 1974 and this aspect of the program is discussed in Section IV of this report.

(c) Tree Crown Conditions:

In 1970, a total of 30 trees or shrubs were tagged at each of the 12 surveillance plots and the "crown conditions" were noted at the time. The crown conditions were again recorded in 1971, 1972 and 1973. The crown condition classification system employed was one developed by the Canadian Forestry Service for hardwood species in Ontario. A classification gradation from 1A (healthy) to 6B (dead), with several intermediate conditions, allowed for an informative description of the crown condition at the time of surveillance.

The table below lists the number of trees which have died or had crown conditions which declined by 1973 for each of the plots:

Plot No.	Distance and Direction from Zinc Plant	No. of Dead Trees	No. of Trees with Declining Crowns
1	1.6 km NE	3	0
2	3.2 km NE	0	0
3	8.0 km NE	1	2
4	16.1 km NE	0	3
5	32.2 km NE	2	5
6	8.0 km E	3	10
7	16.1 km E	1	0
8	32.2 km E	0	5
9	16.1 km SW	0	1
10	32.2 km SW	1	3
11	80.0 km SW	3	2
12	80.0 km E	2	3

Except for plot #6, where moose browsing caused considerable injury, the mortality and decline rates at the surveillance plots were similar to that of the controls. The number of dead or declining trees on all plots represents 13.8% of the total number of tagged specimens. Therefore 86.2% of the trees and shrubs either maintained their position or showed improvement.

It was data such as those above which prompted the Ministry to discontinue the use of plots # 5, 8, 10, 11 and 12 and to concentrate on the area within a 16 km distance of the zinc plant. Since five new plots were recently established, sufficient data are not available for changes in the crown conditions of the trees on the plots for the newly aligned survey. If possible, trees with a crown classification of 1A are selected when a plot is established. Therefore any change from this initial healthy condition will be presented in future reports for the newly established plots.

(d) Growth Studies:

For the aspen trees on the original 12 plots, growth measurements from 1970 to 1973 indicated that the majority of these trees were showing normal height and diameter increments each year.

The following table lists the average increase in diameter (per tree) for the 20 tagged trembling aspens on each plot for the three year period 1970 to 1973 (excluding trees which have died in that period).

Plot No.	Distance and Direction From the Zinc Plant	Average Diameter Increase (per tree) for 20 Trembling Aspens (1970-1973) (Centimetres)
1	1.6 km NE	1.09
2	3.2 km NE	.81
3	8.0 km NE	.99
4	16.1 km NE	1.17
5	32.2 km NE	1.35
6	8.0 km E	1.17
7	16.1 km E	.97
8	32.2 km E	.99
9	16.1 km SW	.81
10	32.2 km SW	.64
11	80.0 km SW	.51
12	80.0 km E	.89

From this table it can readily be seen that diameter growth for the surveillance plots compares very favorably with that at the control plots. These data gave further support to the plan to alter the locations of the study plots.

Heights and diameters of the trees on the newly established plots have been recorded and the progress of these trees will be followed closely in the coming years to determine whether or not the industrial activities in the area are affecting tree growth.

(e) Plant Population Studies:

At each of the original 12 plots which were established in 1970, two 1.0 x 1.0 metre ground cover vegetation grids were set out and the number and species of each type of plant found on these grids were recorded. These tabulations were carried out each August from 1970 to 1973.

In previous annual reports it has been noted that no marked decline in the plant populations had occurred at any plot, even those close to the zinc plant.

A study of the data revealed the following:

(a) The number of species and the number of plants did not differ greatly from grid to grid and from plot to plot.

(b) Any differences in the ground cover vegetation from plot to plot were more attributable to the type and extent of canopy cover, the micro-environment, soil type and climatic factors than to the influence of the zinc plant.

Therefore the recording of the vegetation on these grids was discontinued in 1974. Also no grids were set out at the plots established in the fall of 1973 and the spring of 1974. The grids at the original 12 plots could be re-activated if such action were deemed necessary.

(f) Chemical Analysis Results for Vegetation:

Chemical analysis of the samples collected in 1974 had not been completed at the time of writing this report. However the 1970 to 1973 data have been compiled and subjected to statistical analysis. Levels of arsenic, silver, chloride and cadmium were very low at all plot locations, being at or below the limits of detection in plant tissue. Therefore these values were not included in the data tables. The concentrations of sulphur, copper, iron, lead and zinc in analyzed vegetation samples over four years are reported in tables 1 to 8.

The analysis of variance for the various chemicals in vegetation with respect to species and stations is shown in tables 10 and 11. From these tables the following trends are apparent.

(a) For all elements except arsenic, the variance between the plant species is significantly different at the 5% level with many significantly different at the .1% level. This indicates that the levels of any given element in a single plant species are not necessarily comparable to the levels of that element in other species.

(b) For the combined vegetation analysis, there was not a significant difference in levels of sulphur, silver or arsenic between plots in any year. In 1970, only the levels of cadmium were significantly different between plots. Significant differences in the levels of copper, iron, lead and zinc were found between plots particularly in more recent years. These differences can be primarily attributed to the higher levels of these elements in vegetation collected at plots near the zinc smelter.

These results show that the levels of copper, iron, lead and zinc are significantly different in the combined vegetation analysis at plots 1 and 2, when compared to the remainder of the plots. These facts are indicative of the formation of a zone of metal contamination up to 3 km. to the northeast of the zinc plant. Although copper, iron and lead may be involved, the zinc levels are those which are showing the major increase in this area.

(g) Chemical Analysis Results for Soil:

At the time of the writing of this report the chemical analyses of the soil samples collected in 1974 were not complete. Data from samples collected from 1970 to 1973 have been compiled and statistically analysed. The levels of the various elements in the soil samples collected from the surveillance plots are shown in table 9. From this table it can be seen that the levels of copper and zinc in soils collected at plots 1 and 2 (1.6 and 3.2 km NE respectively) are elevated as compared with the levels of these elements found in soils

collected from the remainder of the plots. It also appears that the concentrations of these two elements have increased each year at both plots.

In 1970 only one soil sample was collected at each of the plots, therefore the metal analysis results could not be subjected to statistical analysis. However an analysis of variance has been calculated for several metals in soil for 1971, 1972 and 1973 when soil samples were obtained twice during the growing season at each plot. A summary of the analysis of variance is presented in table 12 . The analysis of variance shows that the levels of cadmium, copper, lead and zinc in soil were significantly higher at plots 1 and 2 compared to the remainder. This result tends to reinforce the observations made with respect to the levels of several metals in the vegetation at these two locations.

During the 1974 surveillance, soil samples were collected from 3 depths (0-5 cm., 5-10 cm., and 10-15 cm.,) at each location to determine whether or not these metals were restricted to the upper few centimetres indicating recent deposition on the soil surface.

(h) Chemical Analysis Results for Snow:

The results for the chemical analysis of snow samples collected in 1974 and 1975 are presented in table 14. From this data, it is apparent that the levels of sulphate, cadmium, lead and zinc are elevated near the zinc plant and that concentrations of these elements decrease rapidly with distance from the plant. This pattern is shown in figures 5 to 9. The distribution patterns for copper, iron and chlorine in relation to the plant are less apparent. Levels of nickel, arsenic and tin were at or below the detection limit in the 1974 collections therefore analyses for these elements were not performed on the 1975 samples. Concentrations of sodium and calcium measured in the 1975 collections were not significantly different from samples collected in the control location.

The pH of the snow melt water in 1974 was highest near the plant and decreased with distance, (figure 10). These patterns indicate that emissions from the plant are causing increased amounts of sulphur, zinc, lead and cadmium in the snow as well as increasing the pH. Studies of the effects of such emissions on snow and ultimately on the soil in the area will be continued.

(i) SO_2 Measurements:

Analysis of the lead peroxide candles set out at the surveillance plots in the Timmins area has shown that both before and after the start up of the new refinery, only background levels of sulphur dioxide were present in the ambient air. The values expressed as mgm SO_3/100 cm^2/day recorded during the growing season in 1974 are presented in table 13. Only plot 1 (0.8 km northeast of the zinc plant)

showed elevated levels in the rate of sulphation and only in one month (August), but this remained below the Ontario sulphation criterion for desirable ambient air quality of 0.7 mgm $SO_3/100\ cm^2$/day. This higher level can be attributed to a plant operation upset in late July.

IV. Vegetation Injury Close to the Zinc Plant:

Considerable injury to a number of plant species was noted during the 1973 growing season and again during 1974 in the immediate vicintiy of the zinc plant, mainly on company property. During a preliminary inspection in July, 1973 several different injury patterns were recorded on many plant species. It was felt that the following agents could have been responsible for the injury to the vegetation:

1) metal complexes
2) acid mist
3) sulphur dioxide
4) chlorine or chlorides
5) pathogenic organisms

It was decided that an intensive survey of the vegetation around the plant would have to be undertaken to more fully determine the extent of the involvement of each of the above factors.

At the time of the preliminary inspection, the white plumes originating from the two short stacks of the zinc remelt furnaces were being swept along, near ground level, by a brisk breeze from the northeast. These plumes have previously been noted to cross highway 101, at points south and southwest of the plant. It was subsequently determined that the effluent from the zinc remelt stacks contained the following: mainly zinc oxide with zinc and ammonia chlorides, free ammonia, small amounts of zinc sulphide and sulphate, and water vapour. No free chlorine is emitted from this source. Also, from March to May, 1973, problems were encountered with the mist eliminator on the cooling towers which resulted in the release of sulphuric acid mist during upset conditions.

In August, 1973, an intensive investigation of the condition of the vegetation in the vicinity of the zinc plant was undertaken. The degree and extent of the injury to vegetation was noted along south-western, southern and eastern transects from the edge of the industrial complex. To the north of the plant area, bog-type spruce forests on company-owned land predominate, therefore no studies were undertaken in this sector. Observations and sample collections were made at the following locations (distance and direction from remelt stacks). (See map, figure11).

100 metres SW
200 metres SW
1000 metres SW
300 metres E
500 metres E
1100 metres E
100 metres S
300 metres S
8 kilometres E (Control)

The following factors were common to all three transects:

1) the most severely injured species were: raspberry, fireweed, jewelweed and elderberry.

2) other plant species showed varying degrees of injury in the various areas.

3) injury decreased with distance from the plant.

4) injury was restricted to open areas; wooded areas were acting as a filter to remove air pollutants.

5) the balsam fir trees to the southwest of the zinc plant appeared to have been burned by acid mist during upset conditions in March or April, before the onset of the 1973 growing season.

6) the bleached "acid-spots" visible on foliage of many species to the south and southwest of the zinc plant were probably caused by droplets of acid from the "cell house" or cooling towers, landing on the foliage.

7) the prolific symptoms on the raspberry, elderberry, jewelweed and fireweed were more complex to distinquish, although it certainly appeared that the zinc and ammonia chlorides were involved.

In addition to chemical analysis these plant species were examined for the presence of pathological organisms. The pathology report indicated that some of the leaf spots had been caused by disease organisms. However in most cases these organisms were very weak parasites which gained entry into predisposed tissues. Nowhere in the Timmins area were the number of abnormalities as great as around the plant area.

At the various sampling locations balsam fir, raspberry, fireweed, elderberry, balsam poplar and soil (0-5 cm, 5-10 cm, and 10-15 cm) were collected (when available). These samples were analyzed for S, Ag, Cd, Cl, Cu, Fe, NH_4, Ni, Pb and Zn. The results of these analyses were listed in tables 15 to 20. In all cases the Ag and Ni levels were low, therefore they have not been included in the tables. At the time of vegetation collection, special attention was given to such factors as tissue age, the relative position of the sample on the tree with respect to the source, and whether or not the sample contained injured material.

On the charts, underlined once indicates that the levels are markeded higher than the controls; and underlined twice indicates extremely elevated over the controls. From the above tables the following trends were evident throughout the series:

1) Contaminant values decreased with increased distance from the zinc plant.

2) In general, the levels of the various elements in the "not washed" samples were higher than those for the "washed" samples, indicating an external source.

3) The samples collected in the open area showed the highest levels. The trees located at the edge of the wooded areas acted as filters, protecting the vegetation beyond this point.

The main cause of injury appeared to be the build-up of metal-salts such as zinc, iron and copper oxides, chlorides and sulphides causing a desiccation, and sometimes burning of the foliar tissues. Cadmium and lead were involved to a lesser degree. Older tissues were apparently more susceptible than younger tissues. Also, the long, hot, dry period in July probably abetted symptom development on the susceptible tissues during that period. This conclusion would support the visual observation that the majority of the injury was stippled or spotty in character. The white "bleached" spots found on the foliage of several species were the result of deposition of acid mist on very local areas, not allowing for a large build-up of sulphur in the tissue. Also, the balsam fir injury to the southwest, occurred before the onset of the growing season. This was presumably the result of an upset condition in the cooling towers.

For balsam poplar, the only injury occurred to the east of the plant and it appears as though sulphur was involved, both from the visual symptoms and the chemical analysis.

The species with the most prolific symptoms was fireweed. The foliar tissues of this species accumulated large amounts of chlorides, presumably zinc chloride which apparently resulted in the burning of the leaves.

The results of the ammonia analysis were inconclusive; control samples contain higher amounts than the others; injured samples contain less than non-injured etc. Also, washing the samples interferred with the results, therefore only the NW results are reported.

From the results of the 1973 soil analysis, the important feature is that zinc and copper are accumulating in the upper 5 cm of the soil. Sulphur and iron are leachable, therefore they appear uniform throughout. Except for 300 m. E the Pb depositions are still low. The NH_4 and Cd levels are also normal.

In order to improve or alleviate some of the problems encountered above, Texasgulf replaced the broken mist eliminators on the cooling towers and installed a bag-house collector on the stacks of the remelt furnace. This bag-house became operational in July, 1974. The visible plumes from the remelt furnace stacks were thus eliminated.

On June 12, 1974, the vegetation in the immediate vicinity of the zinc plant was examined for possible air pollution injury, especially in the area to the south and southwest where extensive injury was recorded in 1973. No injury was noted on species which were severely damaged the previous season (fireweed, jewelweed, elderberry, bindweed and balsam fir). There was light (6-15% of leaf area affected) intercostal necrosis on the upper surface of some of the raspberry plants. This injury was similar to that noted on the previous year's foliage. Also marginal necrosis was present on the older foliage of

several dandelion plants. Samples of the injured raspberry and dandelion leaves were collected for chemical analysis.

In July, 1974, extensive injury similar to that found in 1973 was recorded on raspberry, jewelweed, elderberry, fireweed and bindweed. This injury was noted mainly to the south and southwest of the zinc plant. The injury patterns were as follows:

a) raspberry - bifacial intercostal necrosis
b) jewelweed - i) brown necrotic leaf spotting
   ii) general reddening of leaves
c) elderberry - blackening of marginal leaf tissue associated with leaf cupping and curling.
d) fireweed - i) marginal necrosis
   ii) leaf spotting
   iii) general reddening of leaf tissue
e) bindweed - intercostal and marginal necrosis.

Samples of raspberry, fireweed, elderberry, jewelweed and dandelion were collected for chemical analysis. As well soil samples (0-5 cm., 5-10 cm., and 10-15 cm.) were collected. These samples were taken close to the 100 m. SW sampling location for 1973. Table 21 compares the results for these samples from 1973 to 1974. These results indicate that the zinc deposition at that location was greater in 1974 than in 1973, while the levels of cadmium, copper, iron and lead remain elevated above those levels recorded for the control samples. Also samples of raspberry collected in 1974 tended to have higher concentrations of copper, lead and zinc in July as compared with samples collected in June. Samples of dandelion collected in July, 1974 tended to have higher levels of sulphur and zinc than did the samples collected in June. These latter two observations indicate a build-up over the season of these elements.

In August, 1974, a more complete survey was conducted in the immediate vicinity of the zinc plant recording injury to vegetation and collecting soil and vegetation for chemical analysis. Vegetation injury similar to that listed above for July was more intense in August and covered a wider area, although the injury was still mainly restricted to the open stretches along the edge of wooded areas. Injury was noted to the northwest, west, southwest, and south of the zinc plant. Heavy construction and severe sulphur dioxide injury obscured these other symptoms to the east of the zinc plant.

Tables 22 to 25 show the levels of sulphur, cadmium, chloride, copper, iron, lead and zinc in trembling aspen, fireweed, forage and soil. For the vegetation the levels of sulphur, cadmium, copper, iron, lead and especially zinc are elevated over the levels found in the control samples. For the soil only, isolated zinc levels appear to be elevated in the upper portions of the profile. However, if the deposition rate such as that indicated from the vegetation samples continues, then the levels in the soils of several elements will show increases in the coming years.

All of these data indicate that contamination of the vegetation close to the zinc plant is occurring. At present this zone

is limited, however there are indications of increases of several metals to the east and northeast at plots 1 and 2 in the surveillance studies.

V. Summary and Conclusions:

In 1970, the Ontario Ministry of the Environment initiated a pre-operational background survey of the environmental situation in the Timmins area where Ecstall Mining Company was expected to construct an electrolytic zinc refinery near Hoyle (20 km NE of Timmins). The refinery was erected adjacent to the ore concentrator which had been operative since 1966. This new zinc plant became operational in April, 1972. From 1970 to 1974, Ministry personnel have conducted an extensive program of environmental analysis and evaluation in the area.

Based on information gathered from the original 10 surveillance plots and 2 control plots, the condition of the vegetation with regard to the number of species, number of plants, growth rate and crown condition has not been altered over the past 4 years. Also, the lead peroxide candle survey showed that (except for 1 reading at 1 plot in 1974) only background levels of SO_2 were present in the ambient air both before and after the initiation of operations at the new refinery.

As a result of a fumigation of sulphur dioxide, severe vegetation injury occurred to the east of the zinc plant in late July, 1974. As well, other vegetation injuries were noted in the immediate vicinity of the zinc plant in 1973 and 1974.

Chemical analysis of vegetation has shown that elevated levels of sulphur and several metals are present in the immediate vicinity of the zinc plant and up to 3 km to the northeast of the plant.

For the 1974 season several of the more distant plots were removed from the survey and replaced with plots located in closer proximity to the zinc plant. This re-alignment should ensure that any environmental deterioration will be properly monitored.

In 1975, a close surveillance in the Timmins area will be maintained to assess any environmental changes in the coming months ahead.

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A P P E N D I X

VII

Plot Locations and Site Descriptions (For Plots Established in 1970)

Plot #1 Location:

1.6 km northeast of the zinc refinery on the south side of Highway # 101 just west of the junction with Highway # 610 in Matheson Township.

Site Description:

Trembling aspen woods with mature to overmature aspen dominant, thinning out naturally with a heavy understory of mountain maple.

Plot #2 Location:

3.2 km northeast of the zinc refinery on the east side of Highway # 610 in Matheson Township.

Site Description:

Open aspen stand on the edge of a black spruce woods. Trembling aspen is the dominant species with a speckled alder understory, and light ground cover. The soil is shallow, rocky and acidic.

Plot #3 Location:

8 km northeast of the zinc refinery on the south side of Highway # 610 just east of Matheson Creek in Matheson Township.

Site Description:

Open aspen woods with a mixture of trembling aspen, balsam popular, and speckled alder with a dense ground cover.

Plot #4 Location:

16.1 km northeast of the zinc refinery on the east side of Highway # 67 just north of the junction with Highway # 610 in Dundonald Township.

Site Description:

Open aspen woodlot with trembling aspen dominant and an understory of alder and hazel.

Plot #5 Location:

32.2 northeast of the zinc refinery, north of Highway # 67 on the west side of Genest Road in Calvert Township.

Site Description:

Dense stand of trembling aspen and speckled alder on a thin, damp, rocky soil.

Plot Locations and Site Descriptions
(For Plots Established in 1970)

Plot #6 Location:

8 km east of the zinc refinery on the north side of Highway # 101 just east of the Frederick House River in Matheson Township.

Site Description:

Trembling aspen dominant with a few scattered balsam fir and a ground cover of beaked hazel, mountain maple, with a few scattered speckled alder and pin cherry.

Plot #7 Location:

6.1 km east of the zinc refinery in Kettle Lakes Provincial Park in German Township.

Site Description:

Open, dry, sandy jack pine woods with an aspen-alder mixture.

Plot #8 Location:

32.2 km east of the zinc refinery on the south side of Highway # 101, approximately 1.5 miles east of Shillington in Currie Township.

Site Description:

Mixed aspen and coniferous woods with many seedlings and saplings and an understory mostly of choke cherry.

Plot #9 Location:

16.1 km southwest of the zinc refinery on the south side of Highway # 101 just east of Schumacher in Tisdale Township.

Site Description:

Open aspen stand on a rocky slope with a speckled alder and balsam fir understory.

Plot #10 Location:

32.2 km southwest of the zinc refinery on the north side of Highway # 101 near the township line between Ogden and Bristol Townships.

Site Description:

Damp woods with trembling aspen dominant and mixed with conifers. The main understory species are speckled alder, mountain maple, viburnum and showy mountain ash.

Plot Locations and Site Descriptions
(For Plots Established in 1970)

Plot #11 Location:

80 km southwest of the zinc refinery on the east side of Highway # 144 in Stetham Township.

Site Description:

Trembling aspen woods on a fine, sandy soil with a beaked hazel and mountain maple understory.

Plot #12 Location

80 km east of the zinc refinery on the south side of Highway # 101 in Michaud Township.

Site Description:

Mixed aspen, spruce and jack pine woods with an alder understory on a well-drained to dry, sandy soil.

Plot Locations and Site Descriptions (1974)

Plot #1 Location:

0.8 km northeast of the zinc refinery, north of the waterline easement and to the east of the concentrator complex in Hoyle Township.

Site Description:

Open aspen woods with a mixture of alder, spruce and balsam fir; shallow soil with numerous rock outcrops.

Plot #2 Location:

1.6 km northeast of the zinc refinery along an abandoned road which links highways 101 and 610, east of the Porcupine River in Matheson Township.

Site Description:

Young aspen stand mixed with serviceberry and other shrubby species. The soil is deeper at this location compared to the other plots.

Plot #3 Location:

3.2 km northeast of the zinc refinery on the east side of highway 610 in Matheson Township.

Site Description:

Open aspen stand on the edge of a black spruce wood. Trembling aspen is the dominant species with a speckled alder understory, and light ground cover. The soil is shallow, rocky and acidic.

Plot #4 Location:

8 km northeast of the zinc refinery on the south side of highway 610 just east of Matheson Creek in Matheson Township.

Site Description:

Open aspen woods with a mixture of trembling aspen, balsam poplar and speckled alder with a dense ground cover.

Plot #5 Location:

16.1 km northeast of the zinc refinery on the east side of highway 67 just north of the junction with highway 610 in Dundonald Township.

Site Description:

Open aspen woodlot with trembling aspen dominant and an understory of alder and hazel.

Plot Locations and Site Descriptions (1974)

Plot #6 Location:

8 km east of the zinc refinery on the north side of highway 101 just east of the Frederick House River in Matheson Township.

Site Description:

Trembling aspen dominant with a few scattered balsam fir and a ground cover of beaked hazel, mountain maple, with a few scattered speckled alder and pin cherry.

Plot #7 Location:

6.1 km east of the zinc refinery in Kettle Lakes Provincial Park in German Township.

Site Description:

Open, dry, sandy jack pine woods with an aspen-alder mixture.

Plot #8 Location:

0.8 km southwest of the zinc refinery on the south side of the Ontario Northland Railway in Hoyle Township.

Site Description:

Open aspen woodlot with trembling aspen as the dominant species; with an alder understory; this is a poorly drained damp area.

Plot #9 Location:

1.6 km southwest of the zinc refinery, on the south side of highway 101, along the road to the abandoned Falconbridge mine in Whitney Township.

Site Description:

Closed aspen stand with a thick understory dominated mainly by beaked hazel.

Plot #10 Location:

16.1 km southwest of the zinc refinery on the south side of highway 101 just east of Schumacher in Tisdale Township.

Site Description:

Open aspen stand on a rocky slope with a speckled alder and balsam fir understory.

Plot Locations and Site Descriptions (1974)

Plot #11 Location:

32 km west-southwest of the zinc refinery on the east side of highway 576, 4.5 km north of highway 101 in Godfrey Township.

Site Description:

Closed aspen woodlot with an understory of choke cherry and viburnum. Under the closed canopy a number of forest flora species make up the ground cover.

Fig. 1.

MONITORING STATIONS IN THE TIMMINS AREA
1970-1973

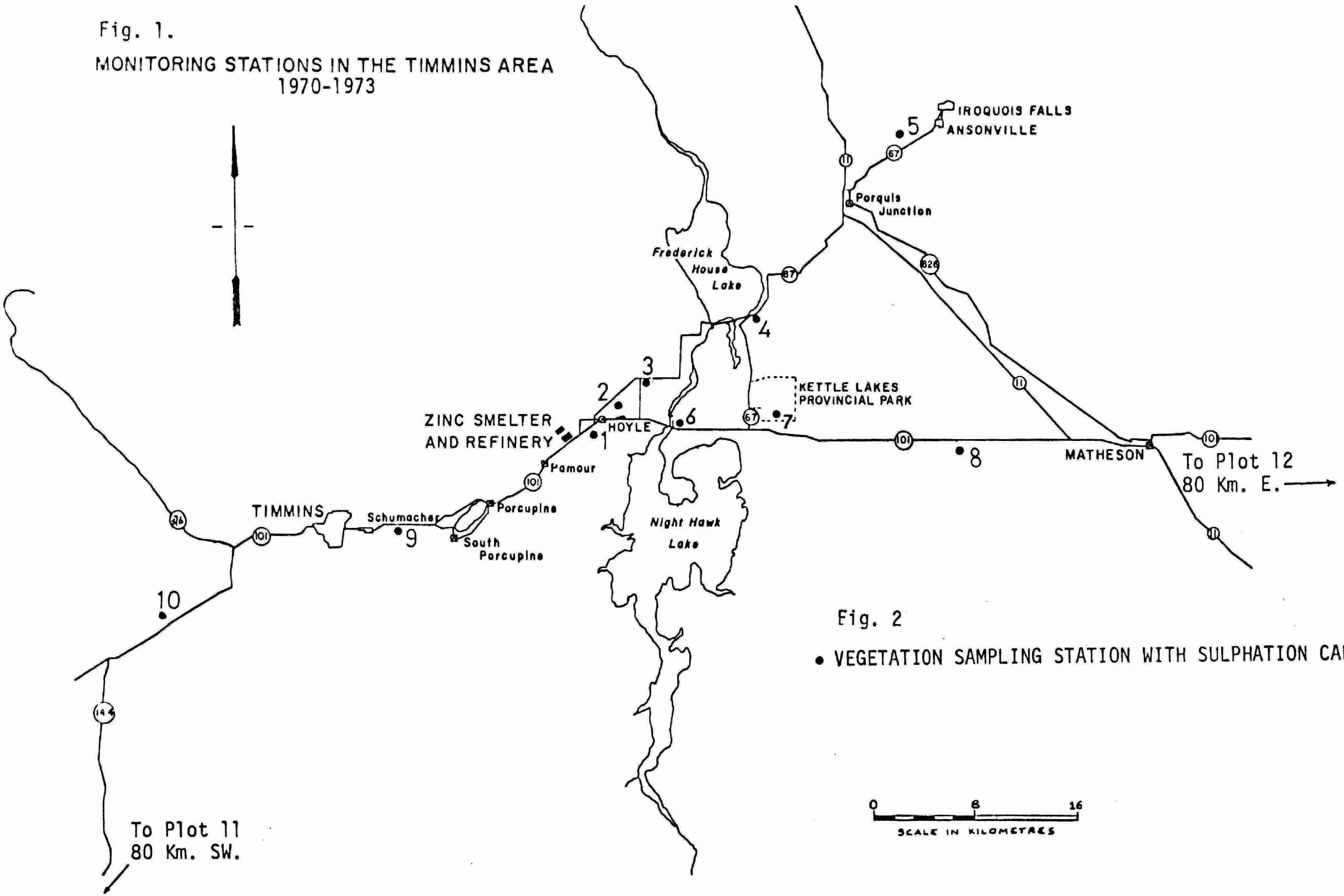


Fig. 2

• VEGETATION SAMPLING STATION WITH SULPHATION CANDLE

MONITORING STATIONS IN THE TIMMINS AREA
1974

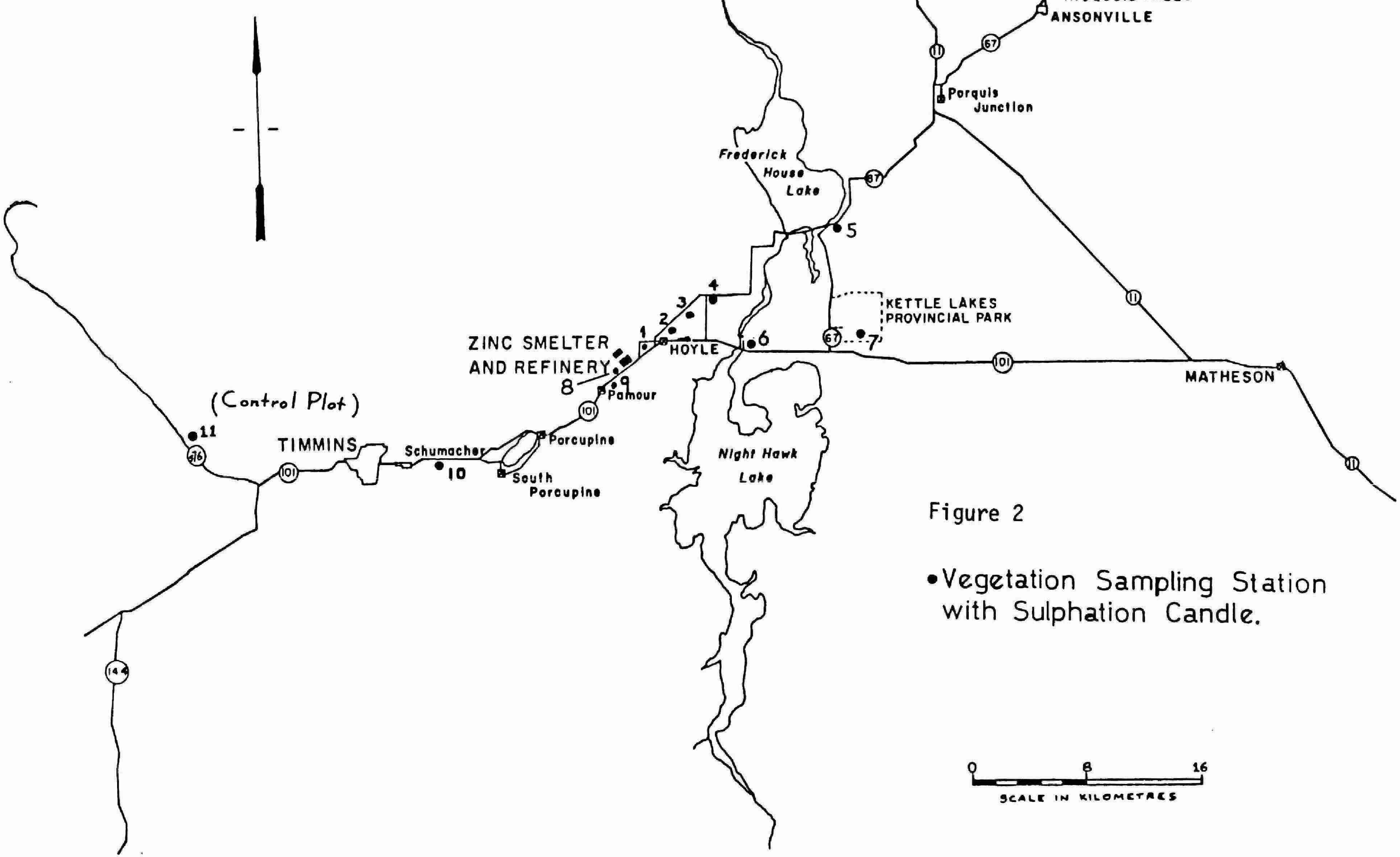
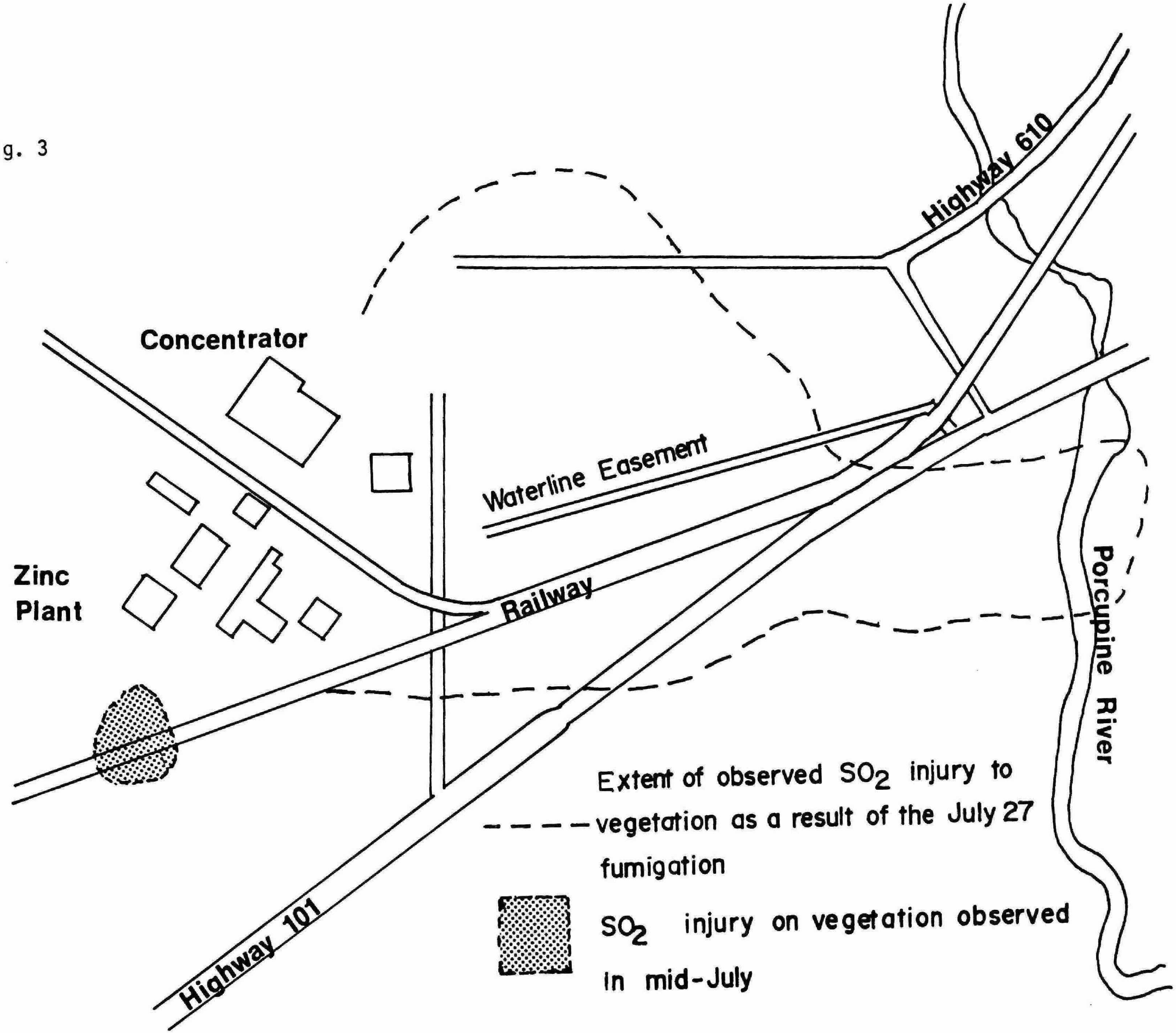


Figure 2

•Vegetation Sampling Station with Sulphation Candle.

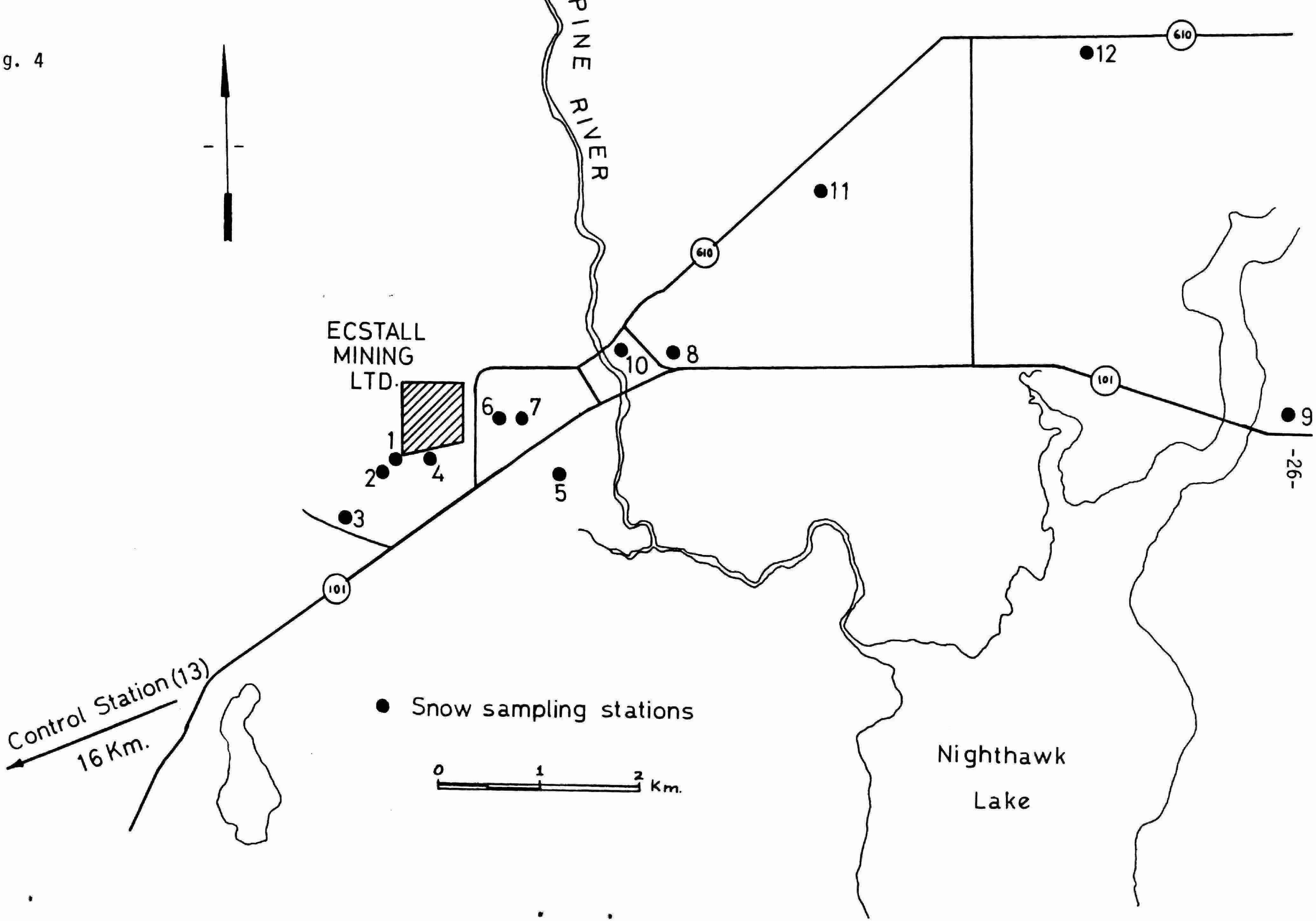
Fig. 3


Concentrator
Zinc Plant
Waterline Easement
Railway
Highway 610
Highway 101
Porcupine River
Extent of observed SO_2 injury to vegetation as a result of the July 27 fumigation
SO_2 injury on vegetation observed in mid-July

SNOW SAMPLING STATIONS IN THE TIMMINS AREA

1974

Fig. 4



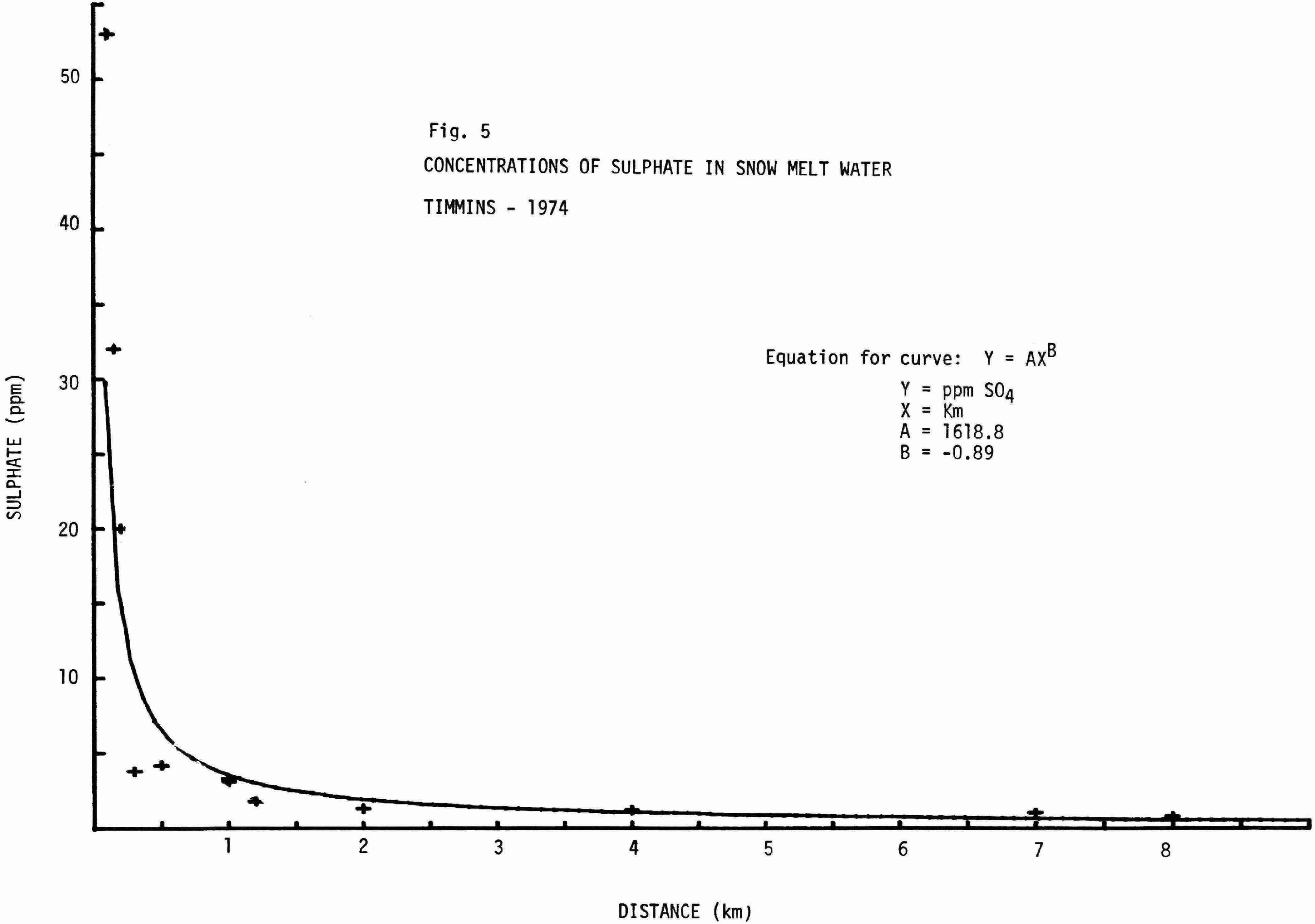


Fig. 5

CONCENTRATIONS OF SULPHATE IN SNOW MELT WATER

TIMMINS - 1974

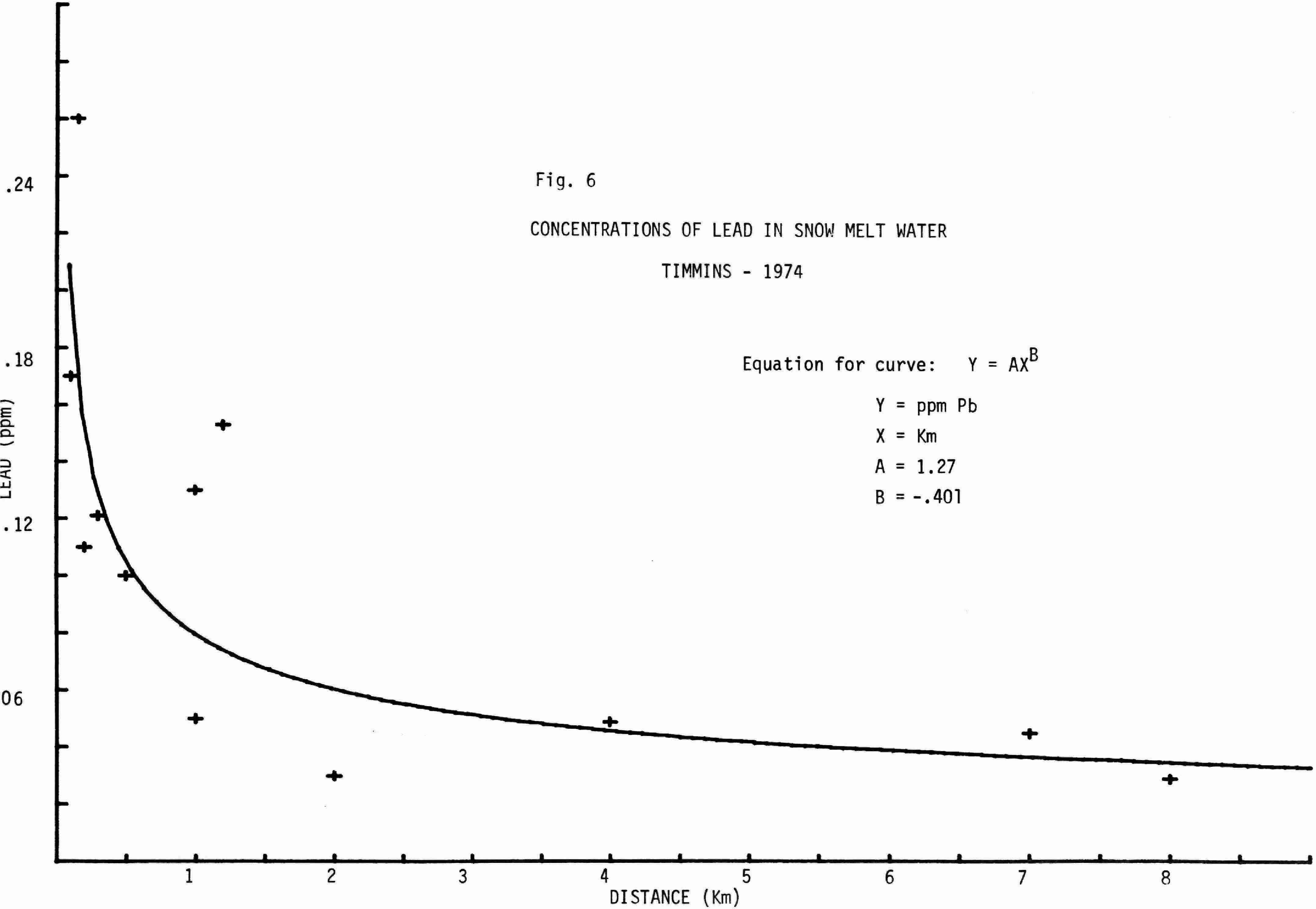


Fig. 6

CONCENTRATIONS OF LEAD IN SNOW MELT WATER

TIMMINS - 1974

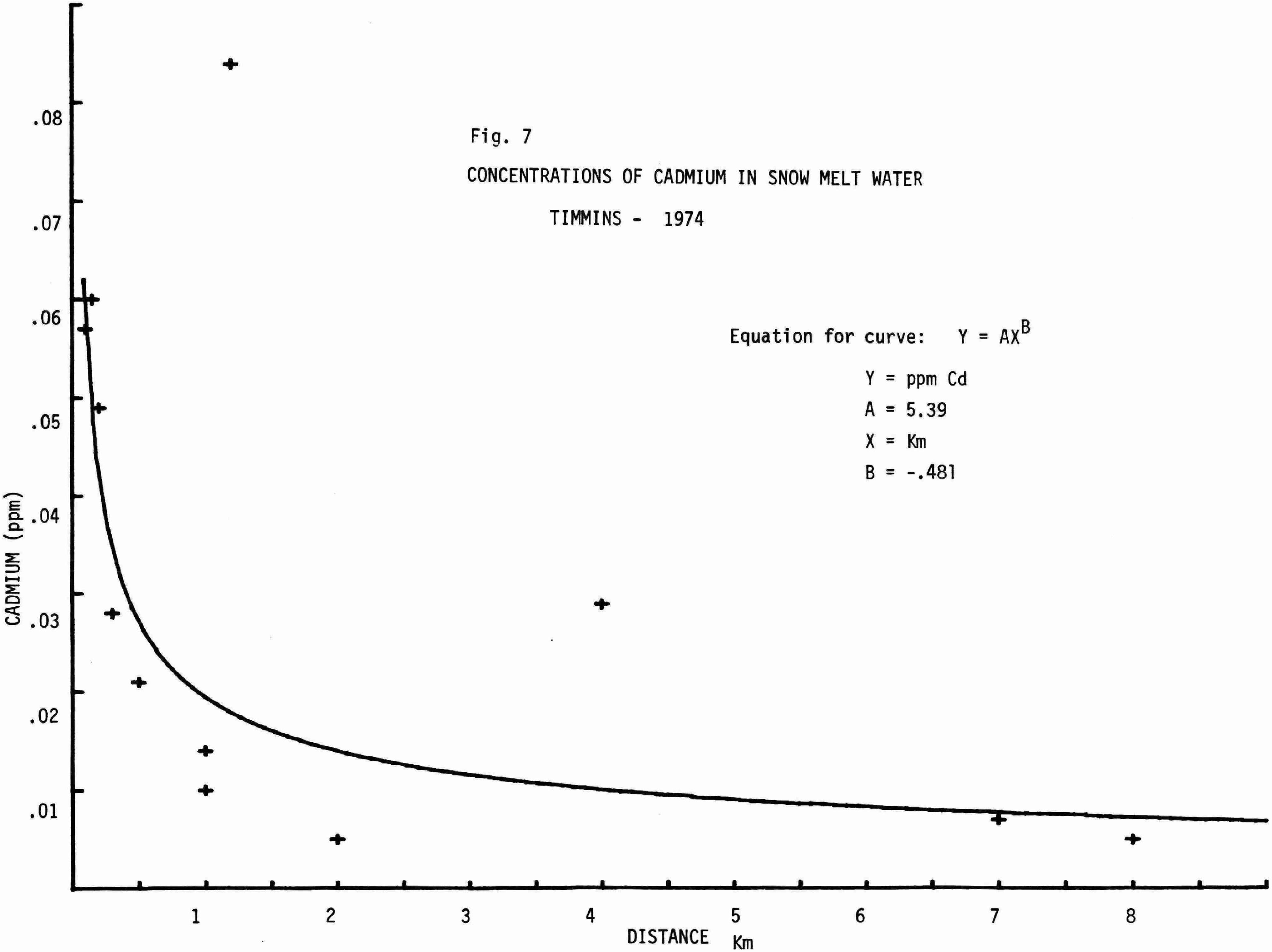


Fig. 7

CONCENTRATIONS OF CADMIUM IN SNOW MELT WATER

TIMMINS - 1974

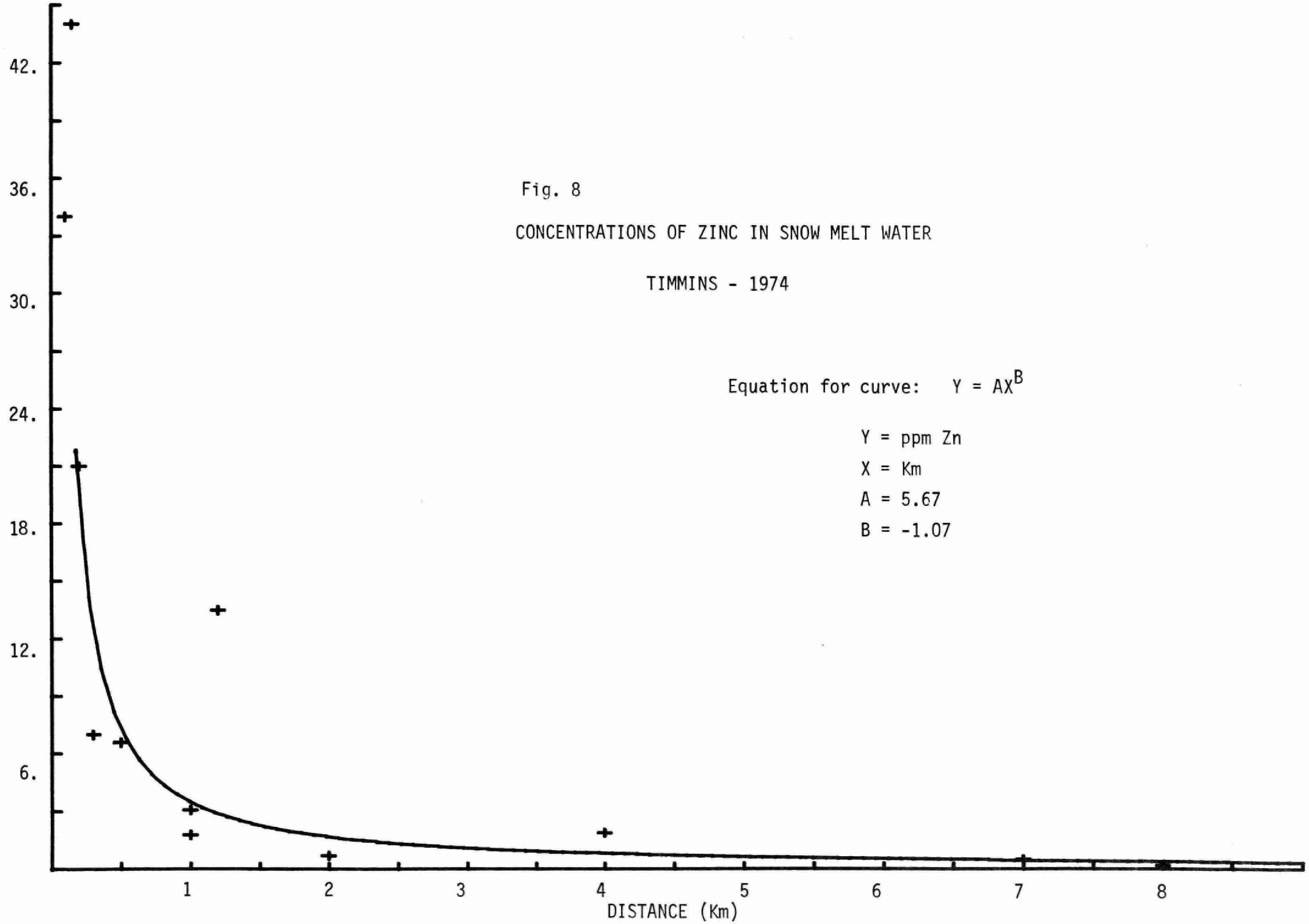


Fig. 8

CONCENTRATIONS OF ZINC IN SNOW MELT WATER

TIMMINS - 1974

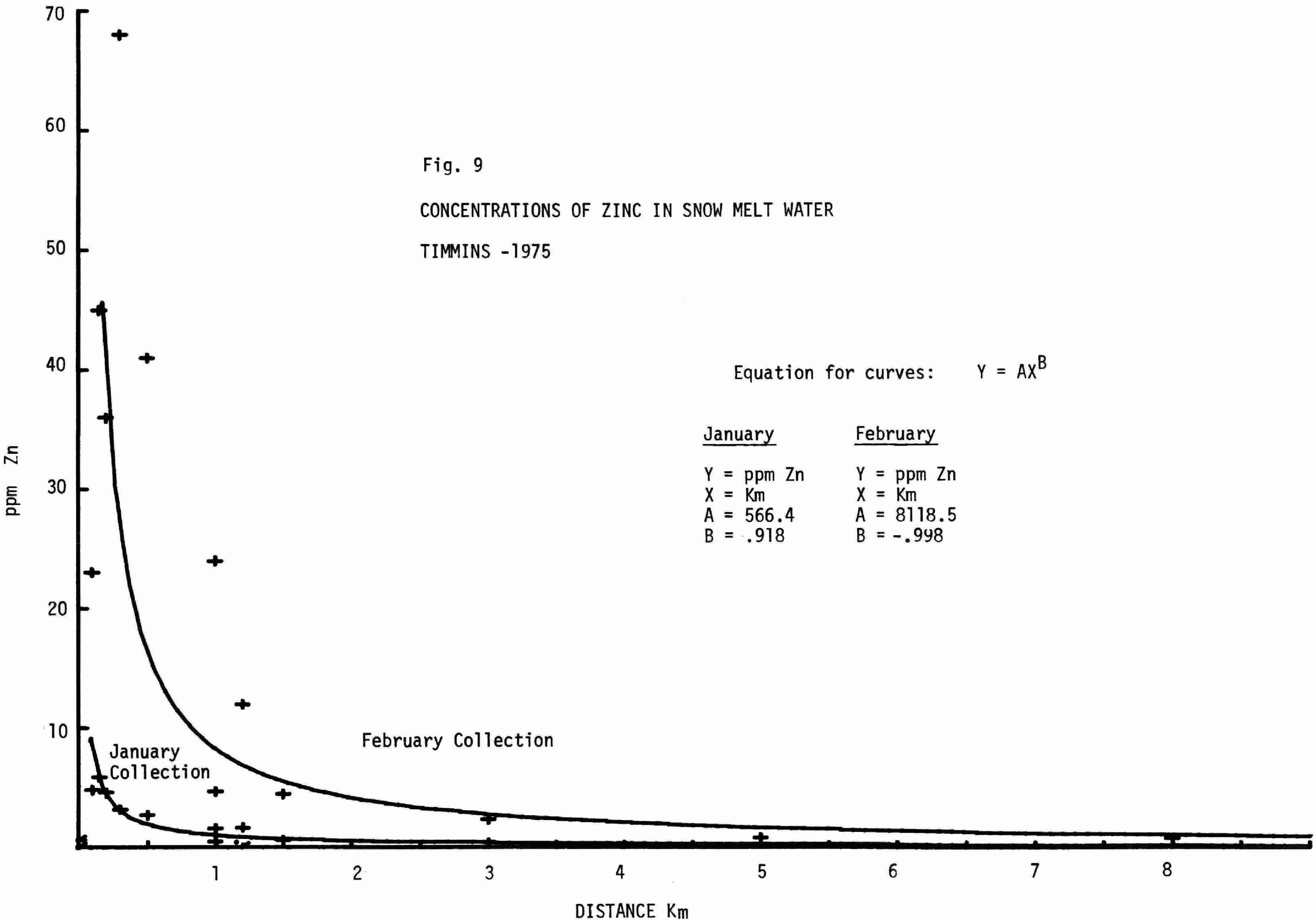


Fig. 9

CONCENTRATIONS OF ZINC IN SNOW MELT WATER

TIMMINS -1975

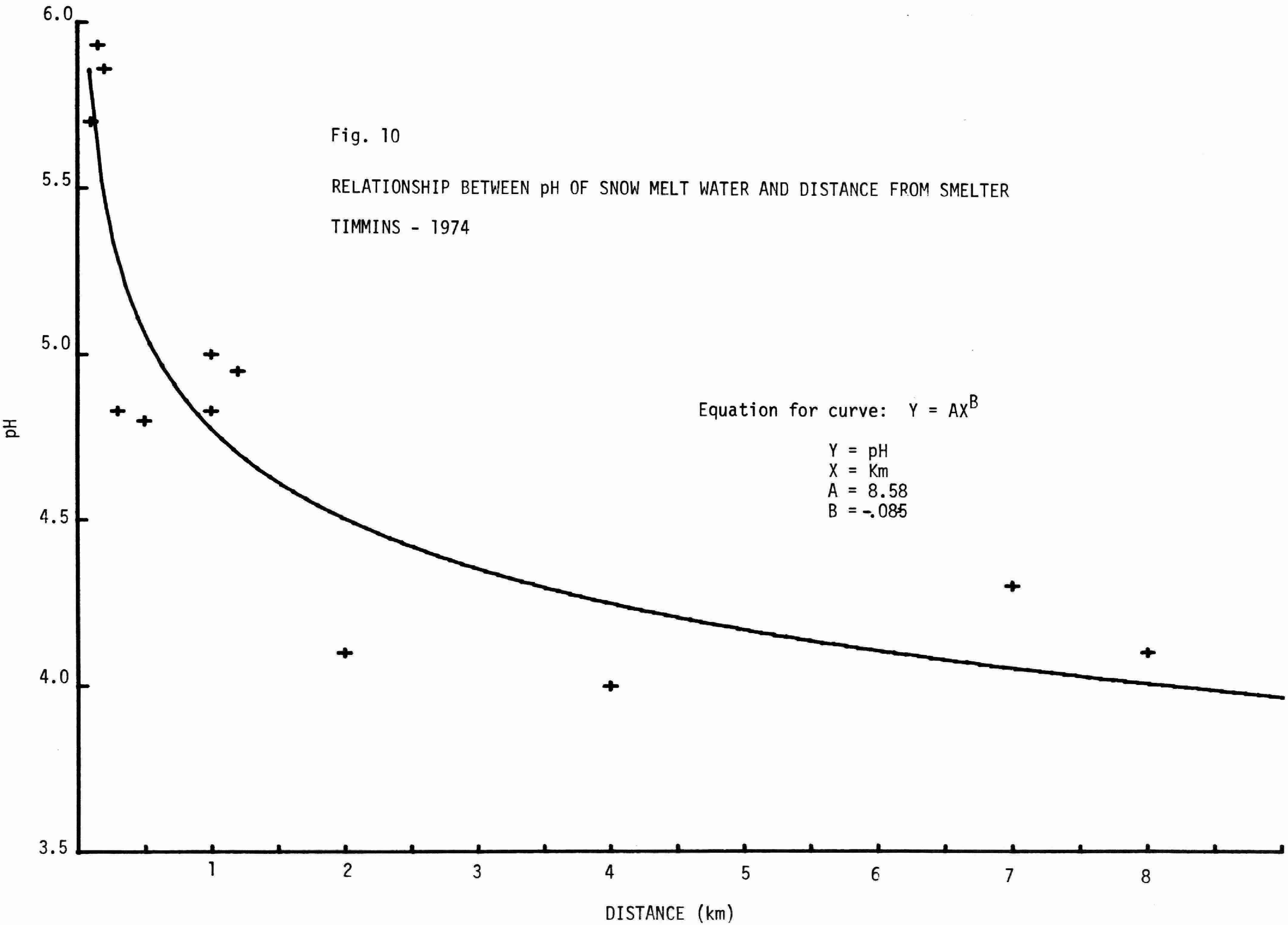


Fig. 10

RELATIONSHIP BETWEEN pH OF SNOW MELT WATER AND DISTANCE FROM SMELTER

TIMMINS - 1974

Fig. 11 SPECIAL SURVEILLANCE CLOSE TO THE ZINC PLANT.

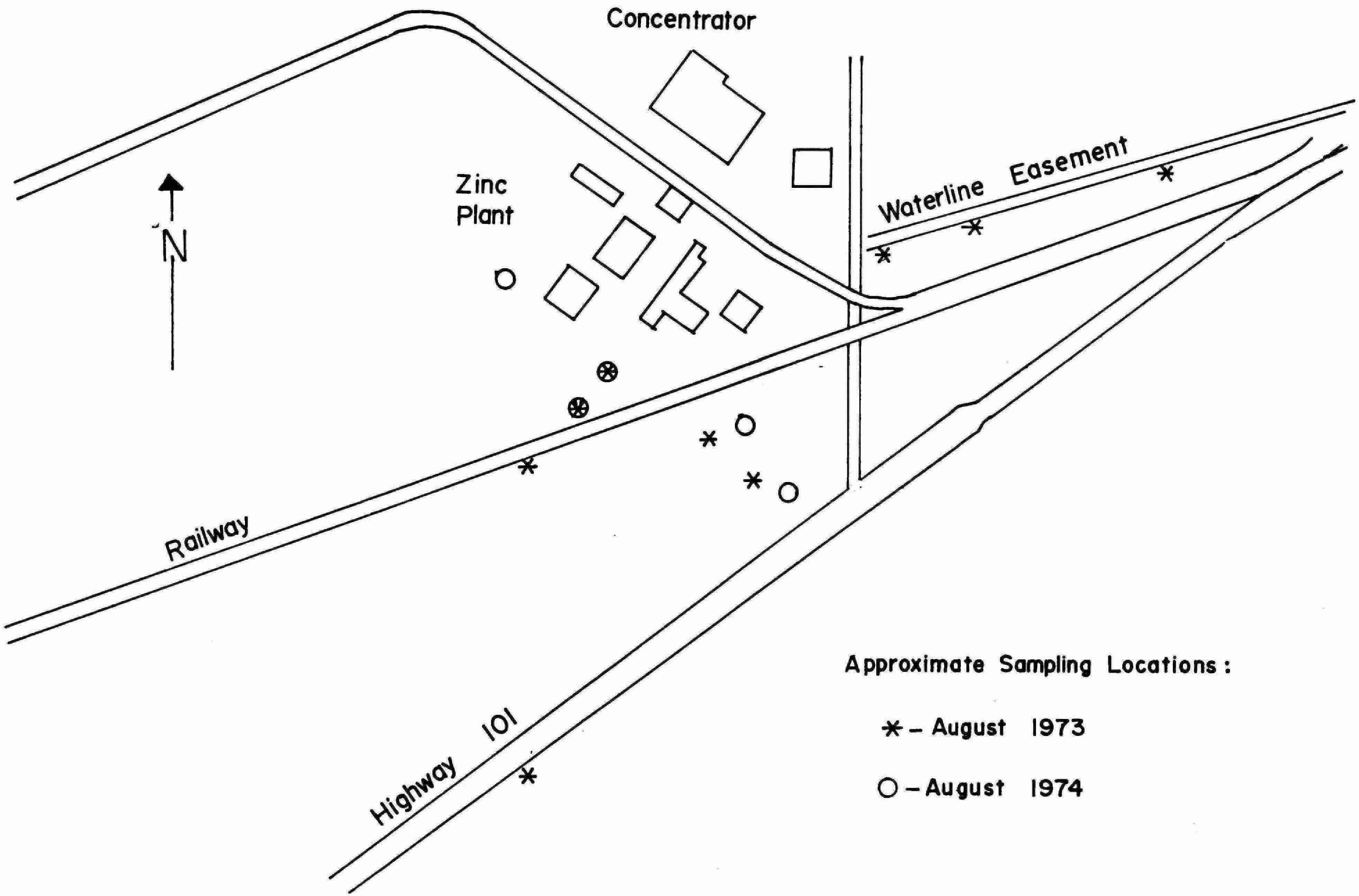


Table 1

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN
JACK PINE NEEDLES (CURRENT) COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS
DURING THE 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF TWO MONTHLY COLLECTIONS)

Jack Pine (Washed)

(Current Year Needles)

Plot No.	* Location	To S %			Cu (ppm)			Fe (ppm)			Pb (ppm)			Zn (ppm)		
		1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
1	1.6 km NE	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	3.2 km NE	.12	.13	.07	6.0	10.3	5	48	52	40	4	8	3	68	90	105
3	8.0 km NE	.09	.11	.04	5.9	3.3	3	55	36	38	4	8	3	68	57	41
4	16.1 km NE	.10	.12	.06	4.8	5.3	2	40	30	34	3	6	2	58	65	27
5	32.2 km NE	.09	.12	.07	4.0	3.5	1	31	47	29	3	7	1	67	62	32
6	8.0 km E	.08	.09	.08	4.1	4.0	4	33	34	36	5	7	6	46	24	69
7	16.1 km E	.09	.09	.08	3.9	3.8	2	44	35	38	2	5	2	52	59	31
8	32.2 km E	.11	.08	.08	3.9	4.5	4	29	35	31	5	5	2	53	62	80
9	16.1 km SW	.09	.13	.03	3.6	3.0	4	50	38	59	11	9	10	54	63	49
10	32.2 km SW	.10	.07	.08	3.6	4.5	3	21	37	33	4	6	3	52	44	55
11	80.0 km SW	.09	.08	.07	2.7	3.5	3	28	36	47	4	5	5	40	47	49
12	80.0 km E	.10	.12	.08	3.8	5.1	3	31	43	26	3	4	3	62	51	67

* Distance and Direction From Hoyle

\- Plots 11 and 12 are Control Plots

Table 2

Jack Pine (washed)
(One year old needles)

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN
JACK PINE NEEDLES (ONE YEAR OLD) COLLECTED AT THE TIMMINS SURVEILLANCE
PLOTS DURING THE 1971, 1972 AND 1973 GROWING SEASONS
(AVERAGE OF THREE MONTHLY COLLECTIONS)

Chemicals

Plot No.	* Location	To S%			Cu (ppm)			Fe (ppm)			Pb (ppm)			Zn (ppm)		
		1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
1	1.6 km NE	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	3.2 km NE	.09	.08	.07	8.6	7.9	20	--	101	134	6	17	12	99	131	195
3	8.0 km NE	.07	.10	.03	2.9	3.0	3	48	52	116	6	12	7	57	61	67
4	16.1 km NE	.08	.10	.05	3.2	3.2	ND	55	52	54	8	12	6	112	70	53
5	32.2 km NE	.08	.08	.07	3.2	3.0	1	70	81	36	8	18	5	66	71	50
6	8.0 km E	.08	.09	.09	4.8	4.2	5	112	80	117	23	23	24	56	58	129
7	16.1 km E	.09	.07	.07	3.1	5.3	4	86	63	42	3	6	3	56	56	37
8	32.2 km E	.09	.07	.08	2.0	3.7	3	38	72	60	7	11	11	112	60	108
9	16.1 km SW	.08	.12	.08	3.9	4.2	5	87	86	110	44	51	18	76	70	53
10	32.2 km SW	.08	.08	.06	2.0	3.6	2	43	48	38	4	9	6	46	47	39
11	80.0 km SW	.09	.08	.07	2.2	3.1	3	66	38	63	5	4	7	29	42	54
12	80.0 km E	.08	.11	.08	3.4	2.9	3	46	48	67	5	7	7	76	38	59

* Distance and Direction from Hoyle
- Plots 11 and 12 are Control Plots.

Table 3

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN WHITE SPRUCE NEEDLES (CURRENT) COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF TWO MONTHLY COLLECTIONS)

White Spruce (Washed)
(Current Year Needles)

		Chemicals														
Plot No.	* Location	To S%			Cu (ppm)			Fe (ppm)			Pb (ppm)			Zn (ppm)		
		1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
1	1.6 km NE	.09	.08	.07	7.8	6.0	7	58	85	31	4	11	4	83	76	170
2	3.2 km NE	.14	.08	.05	7.1	10.0	6	35	43	37	7	10	6	69	105	126
3	8.0 km NE	.10	.12	.06	3.5	6.5	4	17	35	38	3	13	5	48	53	58
4	16.1 km NE	.09	.09	.06	12.2	19.0	5	71	85	57	4	10	3	99	105	49
5	32.2 km NE	.11	.08	.06	5.1	3.8	ND	21	32	40	3	4	3	57	58	39
6	8.0 km E	.09	.10	.06	4.8	4.7	4	25	21	28	3	8	6	60	67	59
7	16.1 km E	.08	.03	.05	3.5	4.3	3	32	45	20	4	2	2	37	34	56
8	32.2 km E	.10	.07	.07	4.3	4.1	3	39	18	21	3	6	3	46	43	49
9	16.1 km SW	.09	.08	.06	4.5	5.0	3	19	22	39	3	11	8	60	74	28
10	32.2 km SW	.10	.06	.05	4.2	7.3	3	32	35	20	3	4	3	55	48	44
11	80.0 km SW	.10	.07	.07	5.3	3.8	4	20	29	23	3	3	4	56	46	43
12	80.0 km E	.12	.11	.07	5.7	5.1	3	27	36	25	2	3	3	43	76	56

* Distance and Direction from Hoyle
Plots 11 and 12 are Control Plots

Table 4

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN WHITE SPRUCE NEEDLES (ONE-YEAR OLD) COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF TWO MONTLY COLLECTIONS)

White Spruce(Washed)
(One year old needles)

Chemicals

Plot No.	* Location	To S%			Cu (ppm)			Fe (ppm)			Pb (ppm)			Zn (ppm)		
		1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
1	1.6 km NE	.08	.09	.06	9.1	8.3	12	79	118	137	5	16	8	87	106	183
2	3.2 km NE	.07	.09	.05	4.4	11.2	9	78	70	64	4	11	6	118	173	176
3	8.0 km NE	.07	.08	.04	2.5	3.8	3	25	26	81	4	8	6	72	54	77
4	16.1 km NE	.10	.12	.06	18.1	33.3	9	141	133	79	6	16	4	151	209	107
5	32.2 km NE	.06	.04	.05	1.5	1.0	4	22	29	44	3	9	3	58	80	40
6	8.0 km E	.09	.09	.06	2.0	2.7	2	23	35	44	5	13	7	93	71	92
7	16.1 km E	.08	.07	.03	1.9	4.5	1	33	39	26	4	4	3	51	37	46
8	32.2 km E	.08	.09	.06	2.4	2.5	1	27	24	26	3	7	4	83	68	61
9	16.1 km SW	.08	.09	.05	2.6	3.2	2	21	38	58	6	19	11	99	80	60
10	32.2 km SW	.06	.07	.04	1.4	3.0	2	30	28	29	7	10	4	74	59	50
11	80.0 km Sw	.06	.07	.05	2.2	2.3	2	35	30	25	4	5	3	39	38	48
12	80.0 km E	.11	.12	.03	3.7	5.7	1	30	34	23	3	7	4	55	100	47

* Distance and Direction from Hoyle

\- Plots 11 and 12 are Control Plots

Table 5

Trembling Aspen
(Washed)

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN
TREMBLING ASPEN COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS
DURING THE 1970, 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF THREE MONTHLY COLLECTIONS)**

Chemicals

Plot No.	* Location	To S%				Cu (ppm)			Fe (ppm)				Pb (ppm)			Zn (ppm)			
		1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
1	1.6 km NE	.22	.23	.32	.26	13.1	15.7	13	67	82	92	90	6	22	7	280	314	470	550
2	3.2 km NE	.22	.23	.34	.19	14.2	--	13	130	97	--	75	10	--	8	300	507	--	614
3	8.0 km NE	.22	.21	.26	.16	9.2	9.0	9	71	52	94	68	4	18	9	270	186	253	147
4	16.1 km NE	.23	.29	.31	.25	9.2	12.5	4	33	50	53	59	6	17	5	265	240	262	279
5	32.2 km NE	.30	.22	.31	.20	9.9	8.8	5	54	62	56	49	4	8	4	140	146	142	131
6	8.0 km E	.16	.20	.21	.17	8.4	8.1	4	46	69	51	57	8	14	6	266	281	207	189
7	16.1 km E	.27	.21	.23	.20	7.0	7.8	8	59	55	63	82	4	7	7	152	132	155	109
8	32.2 km E	.20	.25	.24	.14	8.6	11.0	12	51	39	59	55	5	10	7	250	152	318	197
9	16.1 km SW	.21	.26	27	.20	8.0	9.8	8	38	60	69	80	5	11	15	310	227	191	147
10	32.2 km SW	.24	.25	.24	.20	8.9	9.7	9	46	48	54	55	6	13	6	220	254	365	111
11	80.0 km SW	.24	.21	.24	.20	7.8	9.0	9	47	55	50	57	6	10	9	168	151	151	205
12	80.0 km E	.24	.23	.26	.21	8.6	9.5	10	38	62	56	54	4	7	5	152	146	136	172

* Distance and Direction from Hoyle
\- Plots 11 and 12 are Control Plots
** 1970 Based on One Monthly Collection

Table 6

White Birch (Washed)

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN WHITE BIRCH COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1970, 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF THREE MONTHLY COLLECTIONS)**

Plot No.	* Location	To S%				Cu (ppm)			Fe (ppm)				Pb (ppm)			Zn (ppm)			
		1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
1	1.6 km NE	.14	.20	.32	.18	20.2	32.0	32	33	162	303	148	9	38	13	300	457	590	603
2	3.2 km NE	.13	.12	.25	.11	5.6	--	20	87	141	--	88	9	22	10	820	990	1165	785
3	8.0 km NE	.21	.20	.26	.17	5.5	10.7	8	12	61	131	110	4	12	6	200	95	157	174
4	16.1 km NE	.13	.14	.15	.09	9.9	11.8	2	36	48	57	45	4	15	5	200	228	215	188
5	32.2 km NE	.20	.18	.21	.12	8.7	7.9	5	37	60	84	90	6	11	8	420	367	368	240
6	8.0 km E	.16	.15	.18	.13	5.2	8.7	5	72	80	95	89	6	14	8	150	185	245	243
7	16.1 km E	.13	.19	.21	.16	5.8	10.5	6	13	39	109	76	5	9	6	240	172	266	127
8	32.2 km E	.21	.20	.18	.18	8.3	9.2	11	34	77	66	56	5	11	6	325	218	240	185
9	16.1 km SW	.21	.19	.22	.18	9.6	10.8	7	38	76	86	93	6	10	12	310	179	293	247
10	32.2 km SW	.19	.14	.19	.15	6.5	9.0	7	47	52	54	64	4	13	22	340	309	217	205
11	80.0 km SW	.11	.17	.14	.15	8.2	6.5	8	78	57	50	72	5	8	9	75	152	178	164
12	80.0 km E	.19	.23	.26	.14	9.9	8.9	3	38	78	61	80	6	10	6	24	276	188	185

* Distance and Direction from Hoyle

** 1970 Based on One Monthly Collection

\- Plots 11 and 12 are Control Plots

Table 7

Forage (Not Washed)

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN FORAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1970, 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF THREE MONTHLY COLLECTIONS)**

Chemicals

Plot No.	* Location	To S%				Cu (ppm)			Fe (ppm)				Pb (ppm)			Zn (ppm)			
		1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
1	1.6 km NE	.14	.20	.29	.14	4.2	15.3	2	39	55	107	106	3	9	5	40	28	108	76
2	3.2 km NE	.25	.18	.18	.12	8.2	10.2	6	50	87	131	66	3	12	3	40	78	146	133
3	8.0 km NE	.14	.19	.14	.10	5.7	4.2	1	43	57	122	38	3	6	3	27	9	26	19
4	16.1 km NE	.16	.22	.18	.12	4.1	6.8	4	39	59	51	36	3	10	4	26	63	43	17
5	32.2 km NE	.10	.19	.20	.10	5.1	7.1	4	14	57	89	51	2	8	3	16	21	28	18
6	8.0 km E	.14	.16	.26	.16	3.5	8.0	4	44	64	55	84	3	12	5	30	45	38	26
7	16.1 km E	.10	.28	.19	.13	7.6	5.8	18	87	71	129	212	3	9	5	26	31	21	22
8	32.2 km E	.20	.17	.17	.17	7.6	6.2	2	48	50	39	43	3	8	7	35	32	27	22
9	16.1 km SW	.17	.20	.18	.12	5.9	11.0	4	45	48	63	100	2	18	13	57	60	66	42
10	32.2 km SW	.15	.16	.21	.20	2.7	2.1	5	43	41	41	39	4	8	6	42	35	43	29
11	80.0 km SW	.14	.16	.21	.17	5.7	11.0	5	49	44	42	35	4	12	7	17	26	33	26
12	80.0 km E	.22	.22	.11	.13	8.8	5.0	4	47	55	35	91	3	11	5	28	22	18	41

* Distance and Direction from Hoyle

** 1970 Based on One Monthly Collection

\- Plots 11 and 12 are Control Plots

Table 8

Speckled Alder (Washed)

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN SPECKLED ALDER COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1970, 1971, 1972 AND 1973 GROWING SEASONS (AVERAGE OF THREE MONTHLY COLLECTIONS)**

		Chemicals																	
Plot No.	* Location	S (%)				Cu (ppm)			Fe (ppm)				Pb (ppm)			Zn (ppm)			
		1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
1	1.6 km NE	.14	.19	.35	.18	21.4	30.0	17	10	97	170	115	7	14	8	13	103	189	253
2	3.2 km NE	.22	.17	.35	.19	17.2	--	28	95	107	--	100	5	--	8	100	119	--	305
3	8.0 km NE	.22	.21	.28	.15	9.7	12.2	11	78	87	160	161	4	14	8	33	43	43	58
4	16.1 km NE	.21	.20	.35	.19	10.9	16.0	8	62	62	90	75	6	13	5	39	51	64	71
5	32.2 km NE	.22	.20	.25	.15	15.6	15.2	11	60	67	105	91	5	9	6	44	35	39	30
6	8.0 km E	.22	.19	.22	.17	8.6	10.3	13	25	85	81	79	10	15	8	54	32	44	54
7	16.1 km E	.21	.20	.24	.18	5.9	5.8	5	52	114	73	88	4	5	4	27	26	32	25
8	32.2 km E	.20	--	.19	.18	--	15.0	14	57	--	70	66	-	7	4	45	--	42	66
9	16.1 km SW	.24	.20	.27	.15	9.8	--	8	73	57	--	140	4	-	10	45	36	--	38
10	32.2 km SW	.23	.23	.24	.14	5.7	7.7	13	66	47	71	81	5	13	6	70	39	43	33
11	80.0 km SW	.19	--	--	--	--	--	--	57	--	--	--	-	-	-	33	--	--	--
12	80.0 km E	.18	.23	.20	.20	6.9	9.3	5	10	80	87	83	5	8	5	120	70	41	43

* Distance and Direction from Hoyle

** 1970 Based on One Monthly Collection

\- Plots 11 and 12 are Control Plots

Table 9

CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN SOIL COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS DURING THE 1970, 1971 1972 AND 1973 GROWING SEASONS (AVERAGE OF TWO MONTHLY COLLECTIONS)**

Soil (0-10cm)

Chemicals

Plot No.	* Location	To S%				Cu (ppm)			Fe %				Pb (ppm)			Zn (ppm)			
		1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
1	1.6 km NE	.10	.04	.03	.14	56	88	182	2.32	3.53	3.35	1.16	37	38	50	280	238	327	681
2	3.2 km NE	.20	.18	.17	.21	289	--	346	0.72	2.16	1.15	.91	49	52	32	51	775	1175	1250
3	8.0 km NE	.05	.04	.06	.07	17	15	23	1.65	1.15	1.30	1.19	17	23	24	42	81	34	67
4	16.1 km NE	.01	.11	.03	.05	27	19	25	2.37	3.25	2.65	1.94	31	35	28	100	234	147	168
5	32.2 km NE	.04	.04	.04	.05	19	23	16	2.50	2.42	3.15	1.02	21	37	22	71	221	83	67
6	8.0 km E	.03	.05	.02	.04	31	20	13	4.15	4.23	3.00	1.18	37	27	12	132	201	132	66
7	16.1 km E	.02	.04	.02	.01	4	6	7	0.72	0.48	0.65	.17	8	23	15	39	61	25	57
8	32.2 km E	.15	.15	.01	.08	14	6	5	1.20	1.23	1.02	.23	22	17	14	105	103	49	65
9	16.1 km SW	.04	.03	.05	.12	9	14	18	0.78	0.92	1.01	.21	14	34	42	36	40	63	49
10	32.2 km SW	.01	.05	.06	.02	4	7	ND	0.57	0.64	0.45	.33	12	28	ND	10	28	23	ND
11	80.0 km SW	.02	.05	.01	.04	6	4	ND	0.65	0.56	0.49	.45	12	18	9	24	38	19	10
12	80.0 km E	.01	.04	.01	.02	6	2	ND	0.42	0.72	0.67	.18	13	13	12	11	28	16	195

* Distance and Direction from Hoyle

** 1970 Based on One Monthly Collection

\- Plots 11 and 12 are Control Plots

Table 10

SUMMARY OF ANALYSIS OF VARIANCE (P-VALUES)
FOR SEVERAL ELEMENTS IN VEGETATION IN THE TIMMINS
AREA 1970-1973

Chemical	Sulphur				Silver		Arsenic			Cadmium			
Year	1970	1971	1972	1973	1971	1972	1970	1971	1972	1970	1971	1972	1973
Source of Variance													
Species	.001	.001	.001	.001	.005	.001	.1	.1	.1	.001	.001	.001	.001
Stations	.1	.1	.1	.1	.1	.1	.1	.1	.1	.05	.05	.05	.001

P = 0.1 Not Significant

P = .05 Significant at 5% Level

P = .01 Significant at 1% Level

P = .005 Significant at .5% Level

P = .001 Significant at .1% Level

Table 11

SUMMARY OF ANALYSIS OF VARIANCE (P-VALUES) FOR SEVERAL ELEMENTS IN VEGETATION IN THE TIMMINS AREA 1970-1973

Chemical	Copper			Iron				Lead			Zinc			
Year	1971	1972	1973	1970	1971	1972	1973	1971	1972	1973	1970	1971	1972	1973
Source of Variance														
Species	.05	.001	.001	.01	.01	.001	.001	.001	.005	.001	.001	.001	.001	.001
Stations	.01	.001	.001	.1	.01	.01	.05	.05	.01	.05	.1	.001	.001	.001

P = 0.1 Not Significant

P = .05 Significant at 5% Level

P = .01 Significant at 1% Level

P = .005 Significant at .5% Level

P = .001 Significant at .1% Level

Table 12

SUMMARY OF ANALYSIS OF VARIANCE (P-VALUES)
FOR SEVERAL METALS IN SOIL IN THE TIMMINS AREA (1971-1973)

Chemical	Silver		Cadium			Copper			Iron			Lead			Zinc		
Year	1971	1972	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
Source of Variance																	
Station	.001	.001	.001	.001	.001	.001	.05	.001	.001	.05	0.1	.001	.001	0.1	.01	.001	.001

P =0.1 Not Significant

P = .05 Significant at 5% Level

P = .01 Significant at 1% Level

P = .005 Sigificant at .5% Level

P = .001 Significant at .1% Level

TABLE 13

SULPHATION RATES RECORDED FOR 1974
ON THE LEAD PEROXIDE CANDLES EXPOSED
IN THE TIMMINS AREA EXPRESSED AS
mg SO_3/100 cm^2/day

CANDLE DISTANCE AND DIRECTION FROM HOYLE	JUNE	JULY	AUGUST	MEAN
.8 Km NE	.21	.25	.43	.30
1.6 Km NE	.03	.07	.06	.05
3.2 Km NE	.01	---	.03	.02
8.0 Km NE	.02	.03	.01	.02
16.1 Km NE	.05	.05	.04	.05
8.0 Km E	.00	.02	.02	.01
16.1 Km E	.00	.03	.02	.02
.8 Km SW	.05	.03	.03	.04
1.6 Km SW	.06	.02	.03	.04
16.1 Km SW	.00	.02	.02	.01
32.2 Km WSW	.03	.05	.02	.03

Table 14: CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN SNOW MELT WATER COLLECTED IN THE TIMMINS SURVEILLANCE AREA IN 1974 AND 1975

PLOT NO.	LOCATION*	MONTH**	S (ppm) 1974	S (ppm) 1975	Cd (ppm) 1974	Cd (ppm) 1975	Cl (ppm) 1974	Cl (ppm) 1975	Cu (ppm) 1974	Cu (ppm) 1975	Fe (ppm) 1974	Fe (ppm) 1975	Pb (ppm) 1974	Pb (ppm) 1975	Zn (ppm) 1974	Zn (ppm) 1975	pH 1974	pH 1975
		J	--	9.0	.03	.04	4.0	15.0	.08	.04	.35	.30	.09	.05	11.00	4.80	5.00	4.75
1	100 m SW	F	73.0	12.0	.04	.07	6.0	1.7	.11	.18	1.50	--	.13	.18	42.00	23.00	6.20	5.75
		M	32.0	--	.10	--	3.2	--	.31	--	2.50	--	.30	--	48.00	---	5.90	---
		J	--	7.0	.06	.04	9.0	9.0	.13	.04	1.40	.16	.16	.04	23.00	4.60	5.70	4.85
2	200 m SW	F	24.0	9.0	.03	.07	4.0	1.9	.10	.05	.60	--	ND	.24	25.00	36.00	6.30	5.80
		M	15.0	--	.06	--	1.5	--	.24	--	.65	--	.14	--	16.00	---	5.60	---
		J	--	2.0	ND	ND	4.0	4.9	.04	ND	.20	ND	.07	.03	1.90	.52	3.70	4.50
3	1000 m SW	F	3.0	1.7	.01	ND	1.2	3.5	.03	.05	.30	--	ND	.07	2.90	4.70	5.30	5.20
		M	3.6	--	.01	--	1.5	--	.06	--	.35	--	.04	--	4.40	--	5.90	---
		J	--	8.0	.04	.09	6.0	1.6	.46	.17	1.60	.83	.20	.16	16.00	5.90	5.60	4.80
4	150 m S	F	45.0	17.0	.06	.14	7.5	2.0	.37	1.30	2.80	--	.07	.45	52.00	45.00	6.40	5.80
		M	19.0	--	.09	--	5.0	--	.94	--	1.30	--	.52	--	64.00	---	5.80	---
		J	--	2.8	.02	.01	3.0	3.8	.16	ND	.70	ND	.11	ND	.20	1.60	4.20	---
5	1000 m ESE	F	3.2	5.8	.01	.08	30.0	8.4	.91	.84	.85	--	.17	.23	2.20	24.00	5.20	5.00
		M	3.0	--	.01	--	16.0	--	.22	--	.80	--	.11	--	2.90	---	5.10	---
		J	--	4.1	.06	.02	3.0	9.6	.48	.09	1.00	.53	.21	.09	14.00	3.20	5.10	4.80
6	300 m E	F	3.8	13.0	.02	.11	.5	2.5	.24	1.70	.95	--	.09	.61	3.60	68.00	5.30	5.50
		M	3.8	--	.01	--	.7	--	.10	--	.75	--	.06	--	3.50	---	4.10	---
		J	--	3.5	.02	.02	2.0	1.4	.13	.04	.55	.11	.09	.04	6.30	2.70	4.50	4.80
7	500 m E	F	3.0	7.1	.01	.07	.3	4.4	.13	.75	.35	--	.04	.31	2.80	41.00	5.00	5.30
		M	5.4	--	.03	--	.8	--	.24	--	1.10	--	.16	--	10.60	---	4.90	---
		J	--	1.8	ND	.01	4.0	6.7	.04	ND	.15	ND	.05	ND	.86	.64	3.60	4.65
8	1500 m E	F	1.0	3.7	ND	ND	.4	4.4	.02	.16	.10	--	ND	.09	.41	4.50	4.70	5.00
		M	1.6	--	.00	--	1.1	--	.05	--	.15	--	.02	--	.85	---	4.00	---
		J	--	1.6	ND	ND	2.0	5.0	ND	ND	.05	ND	.04	ND	.24	.11	3.70	4.60
9	8 Km E	F	.8	1.7	ND	ND	.9	6.1	.02	.03	.10	--	.03	.06	.14	.79	4.80	5.10
		M	--	--	.00	--	1.7	--	.04	--	.10	--	.13	--	.13	---	3.80	---

... /2

TABLE 14: Cont'd CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN SNOW MELT WATER COLLECTED IN THE TIMMINS SURVEILLANCE AREA IN 1974 AND 1975

PLOT No.	LOCATION*	MONTH**	S (ppm) 1974	S (ppm) 1975	Cd (ppm) 1974	Cd (ppm) 1975	Cl (ppm) 1974	Cl (ppm) 1975	Cu (ppm) 1974	Cu (ppm) 1975	Fe (ppm) 1974	Fe (ppm) 1975	Pb (ppm) 1974	Pb (ppm) 1975	Zn (ppm) 1974	Zn (ppm) 1975	pH 1974	pH 1975
10	1200 m NE	J	---	3.0	---	.02	---	.8	---	ND	---	.20	---	.03	---	1.7	---	4.50
		F	1.6	4.0	.06	.02	.7	2.4	1.70	.25	1.80	---	.24	.14	13.00	12.0	5.50	5.10
		M	2.0	---	.11	---	.4	---	3.40	---	4.9	---	.07	---	24.00	---	4.40	---
11	3 KM NE	J	---	1.0	ND	ND	2.0	.7	.12	ND	.35	ND	.07	ND	1.50	.44	3.30	4.50
		F	1.4	1.1	.01	.01	.2	1.4	.34	.22	.70	---	.04	.06	2.80	2.40	4.70	4.95
		M	1.0	---	.07	---	.3	---	.23	---	.40	---	.03	---	1.50	---	4.00	---
12	5 KM NE	J	---	1.1	ND	ND	3.0	.5	.04	ND	.15	ND	.05	ND	.31	.17	4.1	4.65
		F	---	1.2	---	.01	---	2.1	---	.07	---	---	---	.04	---	.84	---	4.90
		M	1.0	---	.00	---	.7	---	.10	---	.45	---	.04	---	.72	---	4.2	---
13	16 KM SW	J	---	1.7	ND	ND	1.0	3.8	ND	ND	.15	.21	.04	.06	.06	.05	4.55	4.85
		F	.8	1.0	ND	ND	.7	7.7	.02	ND	.15	---	ND	.16	.06	.08	4.80	4.95
		M	1.2	---	ND	---	1.2	---	.03	---	.25	---	.03	---	.55	---	4.10	---

* DISTANCE AND DIRECTION FROM THE ZINC REFINERY.

** JANUARY, FEBRUARY, MARCH COLLECTIONS.

Table 15: Concentrations of the Various Chemical Elements in Raspberry (not washed [NW] and washed [W])- Collected August 1973

Sampling Location (from remelt stacks)	S % NW	S % W	Cd ppm NW	Cd ppm W	Cl % NW	Cl % W	Cu ppm NW	Cu ppm W	Fe ppm NW	Fe ppm W	NH_4 ppm NW	Pb ppm NW	Pb ppm W	Zn ppm NW	Zn ppm W
100 m. southwest (older-injured)	.11	.13	32	31	.04	.03	79	56	960	660	740	31	24	2770	1810
100 m. southwest (younger-not injured)	.22	.15	7	7	.07	.09	28	25	310	250	880	12	8	920	850
200 m. southwest (older-injured)	.10	.11	5	5	.04	.02	42	37	340	270	1090	12	6	1050	1030
200 m. southwest (younger-not injured)	.16	.15	3	2	.15	.02	32	22	222	156	150	9	7	680	660
300 m. southwest (older-injured)	.13	.11	6	5	.06	.04	75	58	300	260	280	11	10	980	970
300 m. southwest (younger-not injured)	.12	.09	3	2	.03	.07	38	30	220	160	840	7	2	440	380
1000 m. southwest (older-not injured)	.04	.06	2	2	.07	.04	37	35	325	370	560	14	11	380	370
1000 m. southwest (younger-not injured)	.08	.05	2	2	.05	.13	28	27	320	240	480	16	16	290	280
300 m. east (older-injured)	.14	.24	28	27	.26	.22	186	182	1640	1610	490	52	50	4210	4160
300 m. east (younger-not injured)	.24	.23	12	15	.08	.22	100	31	329	376	710	22	27	1550	1680
500 m. east (older-injured)	.15	.14	11	10	.08	.09	114	93	293	276	810	22	21	1730	1660
500 m. east (younger-not injured)	.10	.20	5	5	.05	.04	61	56	227	214	560	14	13	1050	990
1100 m. east (older-injured)	.10	.08	3	3	.03	03	67	54	198	169	320	13	11	630	580
1100 m. east (younger-not injured)	.11	.13	2	2	.02	.02	41	32	142	113	1110	10	8	480	480
100 m. south (older-injured)	.14	.17	15	15	1.11	.61	125	125	537	552	260	33	33	3680	1980
100 m. south (younger-not injured)	.15	.14	6	4	.75	.73	57	33	308	213	570	28	28	710	440
300 m. south (older-injured)	.11	.17	12	4	.91	1.49	66	80	426	543	920	20	20	1470	1260
300 m. south (younger-not injured)	.12	.13	3	2	1.00	.88	19	14	144	103	880	20	18	320	240
8 Km. east (Control-older)	.07	.07	1	1	.05	.02	6	6	201	164	280	21	18	122	119
8 Km. east (Control-younger)	.03	.08	1	1	.02	.02	9	8	144	104	430	21	19	92	79

Table 16: Concentrations of the Various Chemical Elements in Balsam Fir (not washed [NW] and washed [W]) - Collected August 1973

Chemicals

Sampling Location (from remelt stacks)	S % NW	S % W	Cd ppm NW	Cd ppm W	Cu ppm NW	Cu ppm W	Fe ppm NW	Fe ppm W	NH4 ppm NW	Pb ppm NW	Pb ppm W	Zn ppm NW	Zn ppm W
100 m. SW (facing stacks-injured)	.23	.18	45	36	124	109	1330	1150	240	72	67	4170	3100
100 m. SW (facing stacks-no injury)	.16	.13	16	14	74	48	810	590	260	42	42	1470	1120
200 m. SW (facing stacks-no injury)	.14	.12	2	2	18	18	160	226	140	11	11	328	422
1000 m. SW (facing stacks-no injury)	.08	.06	3	2	38	32	520	320	-	28	28	440	350
1000 m. SW (opposite stacks-no injury)	.08	.07	2	2	35	27	-	280	93	12	12	400	310
300 m. E (facing stacks-no injury)	.19	.14	15	10	151	119	1630	920	160	65	59	2380	1230
300 m. E (opposite stacks-no injury)	.22	.17	17	10	162	112	1510	1070	170	56	47	2690	1540
500 m. E (facing stacks-no injury)	.13	.11	2	2	44	40	280	294	60	10	10	330	330
500 m. E (opposite stacks-no injury)	.10	.09	3	3	50	48	390	380	66	17	23	540	440
1100 m. E (facing stacks-no injury)	.10	.10	3	2	42	38	196	170	110	12	12	470	350
1100 m. E (opposite stacks-no injury)	.10	.10	2	1	55	32	202	134	83	22	14	510	360
100 m. S (facing stacks-no injury)	.29	.23	31	20	194	105	680	579	170	149	87	3550	2390
100 m. S (opposite stacks-no injury)	.13	.14	9	9	86	75	572	549	120	71	57	1030	1030
300 m. S (facing stacks-no injury)	.10	.09	6	5	84	72	445	435	79	35	40	660	480
300 m. S (opposite stacks-no injury)	.11	.11	7	6	85	82	534	532	104	65	63	540	490
8 Km. E control	.10	.08	1	1	4	4	81	49	71	18	17	74	55

Table 17: Concentrations of the Various Chemical Elements in Fireweed (not washed (NW) and washed (W)) - Collected August 1973

Sampling Location (from remelt stacks)	S % NW	S % W	Cd ppm NW	Cd ppm W	Cl % NW	Cl % W	Cu ppm NW	Cu ppm W	Fe ppm NW	Fe ppm W	NH_4 ppm NW	Pb ppm NW	Pb ppm W	Zn ppm NW	Zn ppm W
100 m. southwest (injured)	.30	.28	26	22	.26	.23	109	75	720	510	1190	28	20	3850	3770
300 m. southwest (injured)	.20	.15	4	3	.48	.36	46	28	300	180	2980	11	7	770	700
1000 m. southwest (injured)	.09	.07	3	2	.22	.29	25	19	320	170	1730	23	19	400	250
300 m. east (injured)	.31	.31	18	15	.18	.33	106	92	680	560	1850	32	25	2880	2520
500 m. east (injured)	.28	.27	11	9	.17	.19	73	51	234	201	560	23	18	1440	1340
1100 m. east (injured)	.17	.16	2	2	.14	.15	39	37	125	121	1460	11	11	490	430
100 m. south (injured)	.25	.25	20	14	1.28	1.37	156	113	580	507	1610	42	35	2590	2020
300 m. south (injured)	.18	.16	10	6	1.59	1.20	57	42	378	285	880	35	28	1220	840
8 Km. east (not injured) control	.11	.11	1	1	.02	.06	14	17	328	328	2940	23	23	127	143

Table 18: Concentrations of the Various Chemical Elements

in Elderberry (not washed [NW] and washed [W] - Collected August 1973

Chemicals

Sampling Location (from remelt stacks)	S % NW	S % W	Cd ppm NW	Cd ppm W	Cl % NW	Cl % W	Cu ppm NW	Cu ppm W	Fe ppm NW	Fe ppm W	NH_4 ppm NW	Pb ppm NW	Pb ppm W	Zn ppm NW	Zn ppm W
100 m. southwest (injured)	.25	.25	42	41	.06	.06	61	41	670	330	730	28	19	3780	2770
100 m. southwest (not injured)	.33	.29	12	10	.04	.05	45	26	380	190	2070	18	9	1450	750
1000 m. southwest (older-not injured)	.10	.10	1	1	.22	.16	29	22	220	170	920	21	20	300	250
1000 m. southwest (younger-not injured)	.10	.09	1	4	.15	.15	18	14	190	150	900	17	13	250	250
100 m. south (older-injured)	.28	.26	18	10	.09	.20	135	79	579	358	1470	51	40	2450	540
100 m. south (younger-not injured)	.23	.23	3	2	.12	.05	39	26	186	119	1840	24	18	340	250
300 m. south (older-injured)	.19	.14	7	3	1.20	1.28	62	27	358	174	880	36	25	1210	550
300 m. south (younger-not injured)	.16	.17	3	2	1.09	.91	32	19	202	131	860	24	22	540	340
8 Km. east, control (older)	.12	.12	1	1	.04	.05	6	5	81	76	870	24	22	71	62
8 Km. east, control (younger)	.15	.15	1	1	.02	.02	5	4	81	58	3940	17	15	59	55

Table 19: Concentrations of the Various Chemical Elements

in Balsam Poplar (not washed (NW) and washed (W)) - Collected August 1973

Sampling Location (from remelt stacks)	S % NW	S % W	Cd ppm NW	Cd ppm W	Cl % NW	Cl % W	Cu ppm NW	Cu ppm W	Fe ppm NW	Fe ppm W	NH_4 ppm NW	Pb ppm NW	Pb ppm W	Zn ppm NW	Zn ppm W
200 m. southwest (not injured)	.18	.21	3	2	.02	.02	23	23	210	150	390	7	6	670	480
1000 m. southwest (not injured)	.14	.13	2	2	.03	.04	28	16	230	120	320	11	8	420	320
300 m. east (injured)	.50	.47	20	20	.06	.04	119	88	1290	690	280	39	31	3080	2510
300 m. east (not injured)	.44	.38	16	11	.06	.06	108	62	650	410	590	32	22	2550	1850
500 m. east (injured)	.44	.43	13	9	.05	.08	128	79	327	258	250	32	21	1950	1450
1100 m. east (not injured)	.17	.16	11	11	.05	.03	46	31	148	102	440	16	12	136	128
300 m. south (facing plant)	.29	.23	13	7	.23	.17	95	57	478	272	200	49	39	1440	720
300 m. south (opposite plant)	.24	.24	9	5	.18	.12	72	37	374	194	370	42	29	980	530
8 Km. east (control)	.08	.08	2	2	.05	.02	5	5	117	52	170	25	20	140	130

Table 20:
Concentrations of the Various Chemical Elements in Soil - August 1973

Sampling Location (from remelt stacks)		Chemicals S%	Cd ppm	Cu ppm	Fe %	NH_4 ppm	Pb ppm	Zn ppm
100 m SW	0-2"	.039	5	68	1.16	51	23	498
	2-4"	.028	5	38	1.39	58	48	140
	4-6"	.016	5	33	1.44	140	13	120
150 m SW	0-2"	.017	10	93	1.26	70	28	1520
	2-4"	.038	3	20	1.22	36	13	138
	4-6"	.017	3	23	1.41	36	13	95
1000 m SW	0-2"	.022	3	30	1.28	36	20	123
	2-4"	.011	3	30	1.62	17	28	88
	4-6"	.006	3	28	1.36	17	15	70
300 m E	0-2"	.198	8	293	.68	79	128	1180
	2-4"	.132	5	165	.63	23	118	453
	4-6"	.116	5	218	.62	11	178	438
500 m E	0-2"	.330	5	88	1.46	33	13	370
	2-4"	.314	3	33	1.62	40	13	90
	4-6"	.319	3	25	1.45	33	13	88
1100 m E	0-2"	.066	5	68	.74	33	13	518
	2-4"	.061	3	28	.81	26	15	135
	4-6"	.044	5	20	.69	33	18	78
100 m S	0-2"	.138	8	128	1.10	99	28	1290
	2-4"	.017	3	28	1.67	130	18	220
	4-6"	.011	<3	18	1.40	26	20	135
300 m S	0-2"	.198	5	93	.74	117	20	1000
	2-4"	.176	3	63	.66	94	15	738
	4-6"	.111	3	65	1.46	65	28	713
8 Km E	0-2"	.028	3	18	1.38	42	23	238
	2-4"	.017	3	15	1.46	36	13	165
	4-6"	.017	3	18	1.62	29	20	173

Table 21: CONCENTRATIONS OF THE VARIOUS CHEMICAL ELEMENTS IN VEGETATION AND SOIL COLLECTED 100 M SOUTH-WEST OF REMELT STACKS IN 1973 AND 1974

Sample		S% W	S% NW	Cd (ppm) W	Cd (ppm) NW	Cl% W	Cl% NW	Cu (ppm) W	Cu (ppm) NW	Fe (ppm) W	Fe (ppm) NW	Pb (ppm) W	Pb (ppm) NW	Zn (ppm) W	Zn (ppm) NW
Fire Weed	1973	.28	.30	22	26	.23	.26	75	109	510	720	20	28	3770	3850
	1974	.49	.62	11	13	.31	.31	53	93	290	510	39	57	5700	6400
	Control	.11	.11	1	1	.06	.02	17	14	328	328	23	23	143	127
Elderberry	1973	.25	.25	41	42	.06	.06	41	61	330	670	19	28	2770	3780
	1974	.39	.69	11	14	.02	.03	57	103	300	570	33	64	6200	7800
	Control	.12	.12	1	1	.05	.04	5	6	76	81	22	24	62	71
Raspberry	1973	.13	.11	3	4	.10	.09	25	30	290	530	21	36	590	800
(June)	1974	.39	.41	31	32	.03	.04	56	79	660	960	24	31	1810	2770
(July)	1974	.37	.44	12	20	.07	.04	97	165	580	1300	64	128	6900	10500
	Control	.07	.07	1	1	.02	.05	6	6	164	201	18	21	119	122
Dandelion (June)	1974	.62	.64	4	11	1.87	--	43	125	700	1400	19	65	1780	6200
(July)	1974	.84	.96	8	14	.86	.90	34	85	220	920	23	67	2250	5100
Soil (0-5 cm)	1973	--	.039	-	5	--	--	--	68	---	1.16	--	23	----	498
	1974	--	.022	-	4	--	.02	--	40	---	2.28	--	59	----	533
(5-10 cm)	1973	--	.028	-	5	--	--	--	38	---	1.39	--	48	----	140
	1974	--	.022	-	4	--	.02	--	41	---	2.28	--	50	----	260
(10-15 cm)	1973	--	.016	-	5	--	--	--	33	---	1.44	--	13	----	120
	1974	--	.033	-	3	--	.02	--	34	---	2.26	--	45	----	275

W - Washed
NW - Not Washed

Table 22: CONCENTRATIONS OF VARIOUS CHEMICAL ELEMENTS IN TREMBLING ASPEN FOLIAGE-COLLECTED AUGUST 1974

CHEMICALS

SAMPLING LOCATION (from remelt stacks)	S (%)	Cd (ppm)	Cl (%)	Cu (ppm)	Fe (ppm)	Pb (ppm)	Zn (ppm)
100 m. Southwest	.52	11	0.07	32	240	35	8600
200 m. Southwest	.47	5	0.11	30	472	25	2700
100 m. South	.28	5	.08	38	186	20	880
300 m. South	.28	7	.13	21	145	14	1110
300 m. Northwest	.33	7	0.11	25	253	21	600
20 Km. W.S.W (Control)	.20	1	0.10	9	57	9	205

(NOT WASHED SAMPLES)

Table 23: CONCENTRATIONS OF VARIOUS CHEMICAL ELEMENTS IN FIREWEED FOLIAGE-COLLECTED AUGUST, 1974

CHEMICALS

SAMPLING LOCATION (from remelt stacks)	S (%)	Cd (ppm)	Cl (%)	Cu (ppm)	Fe (ppm)	Pb (ppm)	Zn (ppm)
100 m. Southwest	.33	22	.11	34	250	42	10,500
200 m. Southwest	.26	5	.20	27	217	26	5,200
100 m. South	.29	3	.31	42	239	22	1,050
300 m. South	.20	3	.25	25	137	15	1,150
300 m. Northwest	.25	5	.29	38	256	26	800
8 Km. East (Control)	.11	1	.06	17	328	23	143

(WASHED SAMPLES)

Table 24 : CONCENTRATIONS OF VARIOUS CHEMICAL ELEMENTS IN FORAGE-COLLECTED AUGUST, 1974.

CHEMICALS

SAMPLING LOCATIONS (from remelt stacks)	S (%)	Cd (ppm)	Cl (%)	Cu (ppm)	Fe (ppm)	Pb (ppm)	Zn (ppm)
100 metres Southwest	.33	3	.27	13	432	15	3,400
200 metres Southwest	.26	<1	.33	14	103	10	890
100 metres South	.18	1	.27	17	144	8	500
300 metres South	.18	1	.33	12	140	8	360
300 metres Northwest	.20	<1	.33	12	107	8	138
20 Km. W.S.W. (Control)	.14	<1	.02	5	30	4	27

(NOT WASHED SAMPLES)

Table 25 : CONCENTRATIONS OF VARIOUS CHEMICAL ELEMENTS IN SOIL-COLLECTED AUGUST, 1974

CHEMICALS

SAMPLING LOCATIONS (from remelt stacks)	S (%)	Ca (%)	Cd (ppm)	Cl (%)	Cu (ppm)	Fe (%)	Mg (%)	Pb (ppm)	Zn (ppm)
100 m. Southwest (0-5 cm)	.028	2.13	3	.02	40	1.14	1.16	48	315
(5-10 cm)	.017	2.95	3	.02	33	.94	1.38	48	158
(10-15 cm)	.017	3.23	3	.02	28	1.00	1.28	45	118
200 m. Southwest (0-5 cm)	.017	.10	3	.02	33	1.39	.55	40	230
(5-10 cm)	.017	.15	3	.02	40	1.69	.73	43	150
(10-15 cm)	.017	.13	3	.02	48	1.76	.71	40	125
100 m. South (0-5 cm)	.061	1.88	6	.02	45	1.43	.61	48	380
(5-10 cm)	.050	1.63	6	.02	58	1.38	.59	53	610
(10-15 cm)	.044	1.25	4	.02	28	1.03	.40	35	205
300 m. South (0-5 cm)	.149	2.8	8	.02	105	1.20	.45	48	800
(5-10 cm)	.154	3.9	6	.02	68	.99	.39	30	390
(10-15 cm)	.072	2.38	6	.02	35	.83	.32	23	180
300 m. Northwest (0-5 cm)	.080	3.75	3	.02	55	1.92	1.55	53	423
(5-10cm)	.022	1.56	3	.02	35	1.96	1.03	45	180
(10-15cm)	.033	3.00	3	.02	33	1.61	1.43	50	190
20 km. W.S.W. (0-5 cm)	.028	.31	3	.02	44	4.25	1.03	35	170
(5-10 cm)	.039	.31	3	.02	40	3.75	1.00	35	160
(10-15 cm)	.017	.25	3	.02	33	4.00	1.06	28	120